THE ART OF DYEING
WOOL, SILK, & COTTON

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TRANSLATED FROM THE FRENCH

OF

M. HELLOT, M. MACQUER, AND

M. LE PILEUR D'APLIGNY

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INTRODUCTION TO REISSUE

THE names of Hellot, Macquer, and M. Le Pileur D'Apligny, the respective authors of the three treatises included in this volume, are well known to the student of the history of dyeing. They were the forerunners of that long line of French men of science who have done so much for the art and practice of dyeing and kindred industries. They were the immediate precursors of such men as Berthollet, Chaptal, and Chevreul, and like the latter three scientists, they were the greatest authorities of their time on dyeing, and many important improvements were introduced by them. Our British predecessors were not slow to adopt these improvements. In fact the present advanced state of the industry in this country, as well as in France, is directly traceable to the impetus given to the industry by the researches of these chemists.

No doubt practice has altered a great deal since the time these treatises were written, especially since the introduction of the coal-tar colours, but many of the principles inculcated and methods described, are as equally sound and valid as the

day on which they were written. It is therefore confidently anticipated that this reissue will not only be of value from a historical point of view, but will also be of use for purposes of reference and comparison.

The publishers have reprinted the book exactly as it appeared in 1789. The language, although not so terse as that of technical writings of to-day, will be quite intelligible to those connected with the textile industries, as will the many obsolete words, which are explained by the context.

A full index to each of the three parts has been added to this reissue.

LONDON, *August* 1901.

PREFACE

THE great importance of the art of dyeing wool, silk, cotton, and thread in a country whose principal exports are manufactured from these materials, is self-evident. Whether our good neighbours the French be our natural enemies or not, certainly they are our most powerful rivals in commerce and manufactures: in this sense they are our enemies; let us not therefore, from pride or ill-humour, spurn their instructions.

"*Fas est et ab hoste doceri.*"

The art of dyeing is a branch, and by no means the least consequential branch, of chemistry; consequential in its influence on the sale of all stuffs used for furniture or apparel: few people can estimate the intrinsic value of manufactured woollens, silks, or cottons, but men, women, and children can judge of their colours, on the beauty of which therefore the first sale of a new manufacture must depend; and the continuance of that sale will also depend more on the permanency of the colours than on the strength of the stuff; a faded gown is given to Mrs. Betty long before it is worn out.

The government in France, aware of the importance of colours in their various manufactures, hath considered the art of dyeing as an object deserving peculiar attention. Those

who practise this art in that kingdom are subject to certain regulations and frequent inspection. The dyers of the true and of the false dye are distinct occupations, and some of their best chemists have been employed in experiments partly designed to distinguish precisely the true from the false dye, but with the general intention of improving the art.

A circumstantial detail of these experiments, with their various results, are in this volume presented to the English dyers in what I believe to be a faithful translation. I am not a dyer by profession; probably therefore I have not always expressed myself in the language of an English dye-house; but I flatter myself nevertheless that the terms I have used, though not strictly technical, are never unintelligible.

Men of science who are young in the practice of any art are naturally deluded, by a propensity to speculation, into theories which a little more experience would have stifled in the birth. Of these theories the intelligent reader will find some examples in this volume; but, like many other theories, they are perfectly harmless; besides, it is more than probable that the most extravagant speculations of a sensible man may prove a step towards a more rational future investigation of the subject. But be the theories of these philosophical dyers what they may, their experiments cannot fail to be useful to a rational artist.

Several years have elapsed since these three books on the art of dyeing were published in France; and yet those on the "Art of Dyeing Silk and of Cotton" are not at all known by our English dyers: that on the "Art of Dyeing Wool," by Hellot, was partly and poorly translated by a country dyer who knew but little French and no chemistry. The second part of this

volume on the "Art of Dyeing Silk," is the work of the celebrated author of the *Chemical Dictionary,* and must therefore be a very valuable performance, and highly acceptable to every artist in that branch of dyeing. Part the Third is also the work of a very ingenious chemist. His theory is much more rational than that of M. Hellot, and several of his hints may, by a sensible artist, be improved into facts of importance. M. Adanson, of the Academy of Sciences of Paris and of the Royal Society of London, gives the following testimony of this "Treatise on the Art of Dyeing Cotton":—"I have read, by order of my Lord the Keeper of the Great Seal, a manuscript intitled *The Art of Dyeing Cotton, etc.,* by M. P. D'Apligny: this work seems replete with new objects and inquiries likely to lead to new discoveries in the important art of dyeing; therefore it merits the attention of those who wish to assist in bringing this art to perfection."

Having, whilst employed in this translation, frequently laid down my pen to consider the operation of the dyer as a chemical process, I am convinced that the present routine of practice might in many instances be much abridged and improved by a philosophical dyer. An illiterate practical dyer may accidentally stumble on a useful improvement in his art: a chemist unacquainted with the practical part of dyeing may also, whilst in pursuit of other matters, discover results from new combinations that are applicable to the art in question; but the important art of dyeing will never approach the perfection of which it is capable until our dyers by profession can be persuaded to make themselves acquainted with the chemical theory of the art they profess.

These three books which I have translated for the use of

English dyers are an excellent introduction to the study which I recommend; though written some time ago, they exhibit a faithful display of the present practice in France, no improvement having been made in that country since they were written.

I recommend this publication to the perusal of English dyers with great confidence, because I am totally uninterested in the sale of the book, and am the reader's

Faithful Servant,

THE TRANSLATOR.

London, 1789.

CONTENTS

PART II

The Art of Dyeing Silk

PART III

THE ART OF DYEING COTTON AND LINEN THREAD, TOGETHER WITH THE METHOD OF STAMPING SILKS, COTTONS, ETC.

Of Dyeing of Cotton Thread

EXPLANATION OF PLATES

PLATE I

Figure 1 represents two great Coppers, one round, and the other oblong, set in Brickwork on their Furnaces

A. An oblong copper, called by the dyers, oval.
B. A round copper.
C. The scuttle of the chimney.
D. The door of the furnace, below the level of the dye-house.
E. Steps down to the furnace.
F. The leaden pipe by which the water is conveyed to the copper.
G. Cocks placed above each copper, by means of which they are filled with water.

Figure 2 represents the plan of the Coppers, and of the Chimney serving the two Coppers of Fig. 1

A. Plan of the round copper.
B. Plan of the long or oval copper.
C. Stoppers of the furnaces.
D. Space under the chimney, before the furnaces.
E. Steps down to the furnace.

Figure 3 represents the Section of the round Copper; of its Furnace and Chimney

A. The inside of the round copper.
B. The inside of the furnace under this copper.
C. Door of the furnace.
D. Inside of the chimney.
E. Hearth of the furnace.
F. Floor of the dye-house. By this disposition we see that the furnace of the copper is sunk below the floor, that the edge of the copper may not be too high for the workman. In the same manner the floor of the hearth is sunk, for the conveniency of managing the fire.
G. Pipe and cock which convey the water into the copper.
H. Cauldron, or small portable copper.
K. Sieve or strainer.
I Bottom of the sieve.

PLATE II

FIGURE 1 REPRESENTS THE INSIDE OF A SILK-DYER'S DYE-HOUSE, WITH THE DIFFERENT OPERATIONS

A. The workman taking the sacks or pockets, in which the silk had been boiled, out of the great copper.
B. The workman dressing the skeins on the peg.
C. The dyer dipping the silk in the great trough.
D. The workman dipping in the vat.
E. The workman who dry-wrings on the peg.
F. Two men pocketing the silk for boiling.

FIGURE 2

A. A skein of silk.
B. Rods on which the hanks of silk are passed in order to be dyed.
C. Perch or bar for turning the pockets containing the silk whilst boiling, and for taking them out of the copper.
D. A kind of barrow on which the wet silks are laid.
E. Rod on which the hank of silk is put for dipping in the vat.
F. Roucou pot or cullender used for dissolving this ingredient
G. A kind of pestle used for bruising the roucou and passing it through the cullender.
H. A large copper ladle.
I. A small ladle.
K. Pin used for wringing on the peg.
L. Peg.
M. Hatchet for chopping the dyeing woods.
N. A pin or peg.

PLATE III

FIGURE 1 REPRESENTS THE WASHING OF THE SILKS AT THE RIVER

A. Bark in which the dyers stand to wash the silks.
B. Steps from the dye-house down to the river.
C. Plank for passing from the steps to the bark.
D, D. Workmen washing the silk.
E. Workmen who beetles the silk.
F. Stone on which the silk is beetled.

FIGURE 2

A. A cord of silk, or several hanks passed on a cord.
B. Great copper trough.
C. Small copper trough.
The two troughs B, and C, have spouts F, F, F, F, in order to let the water run out which way they please, when full.
D. Great wooden Trough.
E. Stone on which the banks are beetled.

PLATE IV

Figure 1. Indigo Vat, to the level of the Dye-House Floor, with its Brickwork and Furnace

D, D, C. The lower part of the vat, sunk into the ground.
F. Brickwork surrounding the vat.
H. Opening of the vat.
I. Door in the brickwork, on a level with the dye-house floor, answering to the space between the brickwork and the sides of the vat, in which the embers are put for heating it.
K. That part of the body of the vat perceived through the door I.
L. Vent or funnel of the chimney for letting out the smoke of the embers.

Figure 2. Section of the Vat, and of its Brickwork

C. Bottom of the vat sunk in the ground.
E, E. Floor of the dye-house.
F. Thickness of the brickwork.
G, G. Space between the sides of the vat and the brickwork.
L. That part of the vent above the brickwork.
M. The interior opening of the vent into the space round the vat.
N. Door for the embers.

Figure 3

A. Vessel for preserving the Brazil and other woods.
B. Great trough for aluming the silk.
O. Rake for raking the vat.
P. Cover of the vat.
Q. Damper.
R. Poker.
S. Pocket for the silk.
T. Shovel for taking up coals or embers.

PLATE V

Figure 1 represents the Chamber in which the Silk is dried on the Shaker

A. The shaker.
B, B. Hooks on which the shaker is suspended.
C. The workman moving the shaker.
D. The stove.
E, E. Trussels for supporting the poles on which the hanks are strung.

Figure 2

A. The shaker.
B, B, B, B. Hooks and eyes for supporting the shaker.
C, C, C. One of the large sides of the shaker.
D, D. Hooks on the side C, on to which the rods are fastened.
E, E, E. Side of the shaker opposite the side C.
F, F, F. Forks on the side E of the shaker, for receiving the other end of the rods.
G. One of the rods or perches on which the silk is put in the shaker.
H. Two perches with the silk on them, and fixed in the shaker.
I. One of the trussels on which the perches rest.
K. A fork.
L. Hank of silk.
M. Trough in which the silk is washed.
N. A pail or bucket.
O. Vessel for burning sulphur.
P. Cord for moving the shaker.

PLATE VI

Figure 1 represents the Workshop in which they prepare the "Saffranum" or Bastard Saffron

A, A, A. Barks or trough in which they wash the *Saffranum*.
B. Sack containing the *Saffranum*.
C, C, C. Pipe and socks.
D. Workmen treading the *Saffranum*.
E. Hole to let out the yellow liquor.
F, F. A workman bruising the *Saffranum* after it is washed.
G, G. A workman mixing the *Saffranum* with the soda.
H, H. Apparatus for extracting the dye from the *Saffranum* after it is alkalised, by pouring water over it.
I. Workman taking water to pour it on the *Saffranum*.

Figure 2

A. A mortar.
B. Wooden cross for keeping the mouth of the sack open.
C. Pestle.
D. Skimmer.
E. Sieve.
F. Strainer for dissolving the gum in the black dye.
G. Shovel for dividing the lumps of *Saffranum* after washing.
H, H. Apparatus for straining off the *Saffranum* dye.

PART I

THE ART OF DYEING WOOL

INTRODUCTION

Before we proceed to the Art of Dyeing Wool it is necessary to give some idea of the primitive colours, or rather of those which are so called by the dyers; for they have no affinity with those properly so denominated by Sir Isaac Newton. The dyers call them primitive because, from the nature of the ingredients by which they are produced, they become the basis of every other colour. This division of colours is not peculiar to the art of dyeing wool; it is common to the dyers of silk, thread, etc.

The primitive colours are five, viz. blue, red, yellow, fawn or root-colour, and black, each of which furnishes a great number of shades, and from the combination of these shades are produced all the colours in nature. Considerable changes in these several colours are produced by ingredients which are themselves colourless, such as acid, alkaline and neutral salts, lime, urine, arsenic, alum, etc. Wool and woollen stuffs are generally prepared for dyeing by means of some of these. Hence it is evident that an infinite variety of effects must necessarily result from a mixture of these several chemical substances, and from the various methods of using them; hence it is also obvious that the art of dyeing requires some knowledge, scrupulous accuracy, and great attention.

CHAPTER I

Of the Vessels and Utensils used in Dyeing

Your dye-house must be spacious and lightsome, and as near as possible to a running stream, water being absolutely necessary for preparing your woollens, and for rincing them after they are dyed. Your floor should be a mixture of lime and cement, and inclining, so that the water and old vats, which are thrown over it in great abundance, may run off easily.

The most commodious method is to fix two or more vats, according to your quantity of work, about eight or ten feet from your coppers. These wood vats are of the greatest importance, as the setting and heating, that is to say, preparing and properly regulating them, for the blue colour, is the greatest difficulty in the art of dyeing.

These vessels are from ten to twelve feet in diameter, and six or seven feet high; they are made of staves six inches broad and two inches thick; are bound with iron hoops about two or three feet asunder, and are sunk in the ground for the conveniency of managing their contents, which is done by means of hooks fastened to the end of a staff, of a proper length according to the diameter of your vat. The bottom of these vessels is made with lime and cement; but this, however, is not essential, and is practised only because it would be difficult to make a wooden bottom strong enough to support the contents of so large a vessel.

When you mean to dye wool or stuff, prepared according

to my directions in Chapter IV. you suspend within the vessel an iron hoop, with a net fastened to it, the meshes about an inch square. This is called a "cross," and is used to prevent the wool or stuff from falling and mixing with the grounds at the bottom. You may suspend this machine to what height you please, by means of three or four cords fastened to the edge of the vat.

There is another utensil called a "rake," which is a strong semicircular piece of wood, with a long wooden handle. This rake is used for stirring the vat; that is to say, for mixing the grounds with the liquor, and for raising the sediment from the bottom of the vat. It is also used for dashing or plunging the vat; that is, to push the surface quick and forcibly towards the bottom, which by introducing the air forms little bubbles or a kind of froth, by which you may judge of the state of your vat, as I shall explain hereafter.

You must also have a *tranchoir,* which is a kind of wooden shovel used for measuring the lime into the vat; but I shall describe this utensil in my directions for setting the vat, and will, as I proceed, give an explanation of such technical terms as I shall be obliged to use.

The size of these vats, as it depends upon choice or necessity, is undetermined. Vats containing twenty, or even fifteen gallons, are frequently prepared with success; but these small vessels should be surrounded with dung or brickwork, or some other means should be used to prevent them from cooling too fast, else they are liable to fail.

There is also a different kind of vat prepared for blue, called an indigo vat, because it is coloured with indigo only. But the dyers who use the woad vats are not, in general, provided with this. Nevertheless, as it requires a different vessel, a description of it may be useful.

This vessel is generally five feet high, and at the top, two

feet in diameter. It grows narrower downwards, and measures only eight or ten inches at the bottom. It is sunk a foot, or a foot and a half, for the conveniency of working. There must be a cylindrical wall built round it, as high as the vat, upon which the edge of the vat is supported. This wall being perpendicular, and quite straight at the inside, consequently cylindrical, and the vessel which it surrounds of a conic form, it is evident there must be some space at the bottom. In this space the coal and cinders requisite for keeping the vat properly heaped are deposited, and for this purpose there is a little door or opening to put in the coal, which is pushed round the vat, to preserve, as much as possible, an equal degree of heat. The indigo immediately falls to the bottom of this copper vat; but by this method of setting the vat, the fire is above the indigo, consequently it can neither burn nor lose any of its quality. The same precaution should be observed with regard to the Dutch *pastel* vats, as shall be mentioned hereafter.

You must be careful not to extinguish your fire too suddenly, and should therefore fix an iron or stone funnel from the bottom, where the coal is deposited, to the top of the vat. This funnel, for the greater conveniency, should be carried along the wall against which the vat is commonly supported. For stirring the liquor of this vat you must have a rake, but of a smaller size than that used with the *pastel* vat. You may also use a cross; but this however is not necessary, because these small vats are seldom used but for hanks of silk, or worsted; and these are not left entirely loose, lest they should burn; consequently as they are not long enough to reach to the bottom, they cannot touch the ground or sediment.

I have already observed that it is possible to set a small *pastel* vat; but you may, with much less difficulty, set an indigo vat as small as you please. I have myself prepared one in a crystal cucurbit containing one gallon, and another

of one pint only, in a smaller cucurbit. But when I describe the indigo vat I will mention the necessary precautions to be taken for its success.

Besides these vats it is necessary to have several coppers of different sizes, according to what quantity of work you mean to do at one time. They may be either copper or brass; but the copper is better, being less apt to spot where it touches, or when the wool or stuff is suffered to remain in it for any time.

It were also advisable to have a pewter vessel for scarlet, because in pewter the worsted or stuffs never spot, whereas the contrary is much to be dreaded from a copper cauldron. The dyers who make use of the latter for scarlet, take care to have a net of cords or an open wicker-basket at the inside, to prevent the stuffs from touching the copper. The diameter of the net or basket being much smaller than the diameter of the cauldron, there consequently remains a considerable distance between them. But notwithstanding all these precautions, many are of opinion that scarlet dyed in copper is neither so bright nor so lively as when dyed in a pewter vessel. But this shall be the subject of my chapter upon scarlet.

These several cauldrons should be fixed contiguous to each other, and as nearly as possible of the same height, so that the deepest vessel should be sunk the lowest. They should be surrounded by a wall made of brick and clay, the outside of which should have a coat of plaster; and to preserve the whole the wall should be coped with wheel-felloes, held together by iron cramps. The flat edge of the cauldron should be nailed to the felloes with brass nails, because iron nails would spot the stuffs. These felloes serve also to prevent the water, when it boils over, from carrying dirt into the copper. For the same reason a plank should be fixed between the coppers, that when two are employed at the same time, the liquor of

the one may not fall into the other. But this caution will be needless if there be room enough to place these coppers at a tolerable distance from each other.

These cauldrons are heated underneath ; and for the greater conveniency the hearths of all the coppers, as well as the flues, are enclosed under the same chimney. These flues are openings by which the smoke and part of the flame is carried off ; the size of these openings, that of the hearth, and the depth of the furnace (viz. the distance of the bottom of the copper from the hearth where the fire is made) are determined by the size of the coppers; but the mantelpiece of the chimney should always cover every opening, and should project to the edge of the copper, in order to receive all the smoke, so that none may remain in the dye-house. It is scarce possible to give any determined plan with regard to the fixing of these coppers in a dye-house, as that depends in a great measure on your quantity of work.

There should be holes made in the mantelpiece over each of the coppers capable of admitting poles about as thick as your arm, and about five and a half feet above the coppers. These poles are used for draining the hanks of worsted or silk, and for small pieces of stuff, so that the liquor may fall into the copper. For this purpose you pass small rods through all the hanks, which rods rest upon the poles.

When you dye a whole piece of stuff, or several pieces at a time, you make use of a "wince." This wince is a wooden axis with a handle, upon which axis are fastened four flat pieces of wood, at equal distances.

You turn this machine with the hand, resting the two extremes of its axis on two iron forks, fixed into holes in the wooden felloes by which the edge of the copper is supported. You roll one end of the stuff round this wince or reel, and, by turning it quick, wind the whole on to it ; you then turn

it the contrary way, rolling on the other end of the stuff first, and by continuing in this manner you dye the whole as even as possible. If your piece of stuff be rather long, or if you have many pieces to dye of the same colour, you sew the ends together; the reel is then put through the middle, and turned in the manner above mentioned.

If you want to dye wool before it be spun, you must have a kind of wooden ladder, or barrow, very broad, and as long as the diameter of the copper. The cross-laths of this utensil should be very near each other. On this barrow, placed upon the copper, you put your wool in order to drain, or to change the liquor. It were needless to mention the necessity of keeping this barrow and reel very clean. The same attention should be observed with regard to the coppers, and to all the different utensils used in the art of dyeing. It is evident, that without this attention your work will be constantly soiled, and the brightness of the colour tarnished. Hence it is impossible to say too much on the necessity of cleanliness in the several operations of this art.

I shall not describe the other furniture of the dye-house commonly used: they are universally known; such as cauldrons, skellets, buckets, casks, barrels, shovels, wooden covers for the coppers, tubs, foot-boards, mortars, vessels of stone or glass for metallic solutions, pokers, besides many other utensils which need no description.

It is necessary to have a copper ladle for emptying the liquor out of the cauldron after it has yielded all its colour. This ladle has a wooden handle, and contains about two gallons. Wooden bowls are also used for emptying the copper, which is then cleaned with a rush besom and sand, and afterwards wiped and dried with a sponge. In large dye-houses they solder to the bottom of the largest cauldrons a brass pipe with a cock at the outside, in order to empty the copper. This

cock discharges itself into a channel which, passing under the floor, runs off into the nearest drain.

These, I think, are all the instructions that can be given concerning the tools and utensils commonly used in dyeing. If there be any omitted, I shall recollect them as occasion may offer to direct their use.

CHAPTER II

Of the Fixed and Fugitive, commonly called Great and Little Dye

Wool may be dyed either true or false. The first is done by using such drugs or ingredients as to produce a colour so permanent that it is neither affected by the air nor liable to spot; the false colour, on the contrary, soon fades, especially if exposed to the sun, and almost any liquid will spot it in such a manner that it is scarce ever possible to restore it to its original brightness.

It may perhaps seem astonishing that having it in our power to dye all colours true, we should be permitted to make use of an inferior method; but it is difficult, I may say almost impossible, to abolish the custom, for the three following reasons:—first, because this method is in general much less difficult; secondly, the false colours are generally the most bright and lively; the third, and doubtless the most prevalent reason of all, is that the fugitive colour is dyed at a much cheaper rate. Were there no other motive, the dyers would endeavour to avail themselves of the cheapest method; Government, for this reason, hath prescribed certain regulations.

These regulations specify what kind of woollens and stuffs shall be dyed true; and this is determined by the destination of the worsted, and the price of the stuffs. Worsted for working canvas, tapestry, and for all stuffs exceeding forty *sols* an ell, must be dyed true; but coarse worsted, designed for the

tapestry called *Bergame* and *point de Hongrie*, may be dyed false. Such is the purport of M. Colbert's *Regulations*; and those of M. Orry, comptroller-general of the finances in 1733, are grounded upon the same principles. These last have removed a number of difficulties which prevented the execution of the former, with such additions as were necessary for preventing or discovering all possible evasions.

For this purpose, the dyers of the great dye compose a separate body, and are not permitted to employ, or even to keep, such ingredients as are appropriated to the inferior dyers.

As it was impossible, either from the information of the different dyers, or from the study of the *Regulations*, to discover any positive distinction between the true and false, or *great and lesser dye*, it was necessary, in order to ascertain this matter, to take the following method, which though the longest and most difficult is the most certain, or more properly speaking, the only method which could be relied on. The late M. Dufay, of the Royal Academy of Sciences, was chosen by the minister to make these necessary experiments concerning this art. For this purpose he dyed, at his own house, woollens of all colours with every ingredient used in dyeing, whether true or false. He had even brought from different provinces some which were not used in Paris. In short, he collected every drug which he thought might possibly be used for dyeing, and tried them without any regard to the prejudices of the dyers, concerning their good or bad qualities.

He began his experiments on worsteds; but he found afterwards that bits of white cloth were more convenient.

In order to discover which of the colours were permanent and which not, he had patterns of all the colours which had been dyed under his own inspection exposed to the sun and

air during twelve days. This trial was evidently decisive, the true colours being not at all, or but very little, the worse; whereas the false were almost entirely faded; so that, after twelve days' exposition to the summer's sun and night air, there remained very little doubt concerning the class in which the different colours should be ranged.

Nevertheless, as several of these colours had not been exposed to the sun precisely at the same time, nor in the same season, there still remained a doubt; for some of them, having had more of the sun than others, were more faded in the same number of days. This inconvenience, however, he remedied in such a manner that there remained no longer either doubt or difficulty with regard to the sufficiency of his trials. He pitched upon one of the worst colours, that is to say, the colour upon which the sun had had the most sensible effect in the space of twelve days. This colour served him as a standard through the whole course of his experiments; for whenever he exposed his patterns he also exposed a pattern of this piece of stuff at the same time, no longer attending to the number of days, but to the colour of his standard, which he left out until it became as much faded as those which had been exposed for twelve summer days. As he constantly made a memorandum of the day when he exposed his patterns, he found that, in winter, four or five days were sufficient to bring them to his standard. By pursuing this method there remained no longer any doubt concerning the accuracy of his experiments.

But in these experiments he had still another object in view, viz. to find a proof-liquor for every colour, that is, a liquor in which the stuffs are boiled, in order to discover whether the dye be true or false. He boiled his patterns in a solution of alum, of tartar, of soap, in vinegar, in lemon juice, etc., and by their effect on the colour he was enabled to judge of its

quality. The several liquors used till the year 1733 were not decisive. They sometimes discharged a good colour, without doing much damage to a bad one. He was therefore obliged to establish several, each of them serving for a certain number of colours, as will be seen at the conclusion of this treatise; it may be necessary, however, to add a few words to show the method he pursued in the discovery of these proof liquors.

Having perceived the effect of the air upon each colour, he tried different kinds of solutions on the same pattern, and fixed upon that which had made a change on the colour equal to what the air had produced. By ascertaining the weight of the matter dissolved, the quantity of water, and the time of trial, he was certain of producing the same effect on the colour as would be produced by the air, supposing both patterns to be dyed in the same manner. Having tried all colours, and every ingredient, he, by this means, which one might think infallible, ascertained the good and bad qualities of every colour, by thus, as it were, analysing each ingredient. It were unjust not to acknowledge M. Dufay's ingenuity in his method of discovering the reality and stability of colours by boiling; for it is evident that trials by exposition to the air and sun is impracticable in cases where immediate determination is required, as when goods are bought at fairs.

The proof-liquors of the new *Instructions*, published in consequence of M. Dufay's memoir, discharged in a few minutes as much of the colour, if not of the great dye, as would have been lost by exposure to the air for twelve or fifteen days. But as general rules for such trials are liable to many exceptions impossible to be foreseen or explained without creating confusion and innumerable disputes, it follows that rules which are too general may be also too strict, in many cases, where

the light colours require either a smaller quantity or less active salts than the darker colours, which may lose a considerable quantity of their colouring ingredient without any very visible alteration. It should therefore seem necessary to prescribe a different liquor for every shade, which, considering their infinite variety, would be impossible. Hence the air and sun is the best criterion, and therefore every colour which is proof against their effects for a certain time, or which thereby becomes of a deeper colour, ought to be deemed good, even though it should be altered considerably by the liquor prescribed in the new *Instructions.* Scarlet, for instance, this colour being almost entirely discharged by soap, was submitted to a trial of alum. If dyed with cochineal only, without any other mixture or colouring ingredient, it will become purple. Nevertheless, scarlet exposed to the sun loses a great part of its brightness, and becomes deeper; but this deep shade is different from the colour which it acquires from the alum. Hence proof-liquors, in certain cases, cannot be substituted for the air and sun, at least as to the similarity of effect.

From the Brazil wood I have obtained a much finer red than that of madder, and as bright as that procured from the grain of kermes. This red, by means of a particular preparation, which shall be mentioned in proper time, being exposed to the air during the two last months of the year 1740, which was, as may be remembered, very rainy, and during the two first months of the year 1741, notwithstanding the rain and and bad weather, proved very permanent; and so far from fading, acquired a deeper shade. Nevertheless this colour yielded to a solution of tartar. Ought it therefore to be condemned? Are stuffs used for garments to be boiled with tartar, alum, or soap? I do not, however, presume to disapprove of trials by liquors; they are useful because quick;

but in some cases, not sufficient for condemnation, especially as they do not determine whether a colour be dyed *in grain* or *not in grain*. Having given these preliminary ideas respecting the distinction of colours, it is necessary to describe the practice of the dyers of each class.

CHAPTER III

Of Colours in Grain

All permanent colours, as I have already said, are called true colours, or colours *in grain*, and the others, not in grain, are false colours.

I have learnt from experiment, the best guide in philosophy, as well as in the arts, that the difference of colours, according to the preceding distinction, depends partly on the preparation of the subject to be dyed, and partly upon the colouring materials. Hence I am of opinion that it may be received as a general principle of the art in question, that the invisible mechanism of dyeing consists in dilating the pores of the body you mean to dye; to deposit in them the particles of a foreign substance; to confine them by some kind of cement, so that neither rain nor sun can possibly alter them; to choose the colouring particles of such a tenuity as to penetrate and be retained by being sufficiently wedged into the pores of the subject when dilated by the heat of boiling water, and afterwards contracted by cold, and finally covered with a kind of mastic, left by the salt used in preparation. Whence it follows that the pores of the fibres of the woollen, either fabricated or to be fabricated into stuffs, ought to be cleansed, expended, cemented, or glued, and then contracted, that the colour-atoms may be retained, or fastened, as it were, like a diamond in the bezel or collet of a ring.

From repeated experiments I am also taught that every

ingredient for dyeing in grain has in some degree an astringent and precipitating quality; that this quality is sufficient to separate the earth of alum, one of the salts used in the preparation of wool before it be dyed, and that this earth, mixed with the colouring atoms, forms a kind of lacquer something like what painters use, but infinitely finer; that in bright colours, such as scarlet, where alum cannot be used, it is necessary to substitute for this earth, which is always white when the alum is good, some other body that may supply the colouring atoms with a basis equally white; that tin gives this basis in the scarlet dye; that when all these minute atoms of the colouring earthy lacquer are distributed through the pores of of the dilated subject, the gluten which the tartar (another salt used in the preparation) deposits serves to cement these atoms, and finally, that the contraction of the pores occasioned by the cold confines them.

Probably the false colours are defective only because the subject is not sufficiently prepared; and the colouring particles being deposited only on the smooth surface, or in pores not enough dilated for their reception, the least accident must inevitably detach them. If a method of supplying colouring parts of dyeing-woods with the necessary astringency could be discovered, and at the same time the wool properly prepared, as it is prepared to receive the red of madder, I am convinced, from at least thirty experiments, that these woods might be rendered as useful to dyers in grain as they have hitherto been to the second class of dyers.

I shall give a proper application to the preceding rules in the sequel of this work, where I shall not fail to explain what has determined me to adopt them as general principles.

What are called by the dyers, *primitive colours*, are five in number, viz. blue, red, yellow, fawn colour, and black. I shall not, in this place, give a tedious and almost needless

description of every ingredient necessary for dyeing these colours in grain, nor yet of those which are only used in false colours; neither shall I mention those which are prohibited on account of their bad qualities of fretting, hardening, and destroying the wool. The reader is yet ignorant of these ingredients, and I think it best not to mention them till I treat of the particular colours in the composition of which they may be introduced. Those who would choose to see a catalogue of these ingredients, collected under one view and ranged in their proper classes, according to their good or bad qualities, need only consult the *Regulations*.

I now proceed to examine the five primitive colours above mentioned, and will give the different methods of preparing them, in a solid and permanent manner, conformable to the *Regulations for Dyers in Grain*.

CHAPTER IV

Of Blue

Wool or woollens to be dyed blue require no other preparation than that of soaking them well in common warm water, and then squeezing or draining. This precaution is necessary in order to facilitate an equal introduction of the colour into the body of the wool. The same preparation is necessary for colours of every kind, and requisite both for worsted and woollen stuffs.

Wool in the fleece, for the fabrication of cloth, either to be mixed or otherwise, and which for this reason is obliged to be dyed before it be spun, requires a different preparation in order to take out the grease, viz. to deprive it of the natural fat which it has imbibed from the animal, and which is never extracted till prepared for being dyed [*the natural fat adhering to the wool preserves it from being fretted by the moth.*] This operation being the business of the dyers, and indispensably necessary for all woollens which are to be dyed before they are spun, be the colour what it may, I shall now describe. The process is not, however, always exactly the same; but the following is the method used in the manufactory at Andely in Normandy, where cloth is remarkably well fabricated:—

They put twelve buckets of water and four of fermented urine into a large copper capable of holding twenty buckets. The copper is then heated till you can bear your finger in the liquor, into which they throw ten or twelve pounds of wool in

its natural state, viz. before it is cleaned. They suffer it to remain in the copper about a quarter of an hour, stirring it with a stick from time to time: it is then taken out, and set for a moment to drain on the barrow or ladder (mentioned in the description of the dyeing utensils), from whence it is carried in a large square basket, which basket is put into a running water, where two men keep moving it for a considerable time from one to the other with long sticks, till the fat is entirely extracted. While any of this fat remains in the wool the water is whitish and muddy, consequently when the water is clear it is a sign that the wool is sufficiently clean; you then take it out and put it in a hamper to drain. While the first wool is in the basket you put into the copper a second parcel of an equal quantity, and so on till your wool is all clean. If the liquor diminishes too fast the copper must be replenished with the same composition of one part urine to three parts water. They generally scour a bale of wool at the same time. If it weighs 250 pounds while fat, it generally diminishes 60 pounds, and when clean and dry, weighs no more than 190 pounds. It is evident that this diminution must vary according to the quantity of fat contained in the wool, or in proportion to the accuracy of its extraction. But it is impossible to be too urgent upon the subject of cleaning the wool, because it is thereby better disposed to receive the colour.

This sweat or fat is in some degree a urinous perspiration of the sheep, which is prevented from flying off by the thickness of the fleece, where it is retained, being indissoluble in water; hence water alone cannot scour it; a fourth part urine is therefore added to the copper; but this urine should be kept till it begins to smell, in order to develop the volatile salts by fermentation. These volatile salts, being an alkali, form with the grease a kind of soap, which is always produced by the union of an oily substance with any alkali whatsoever. As

soon as the soap is formed by the combination of these two substances, it is soluble in water, and therefore easily washed out. Soap is evidently formed by this operation, because the water which carries it off becomes milky. If the copper has been supplied with enough of the fermented urine for the quantity of the grease adhering to the wool, it will be perfectly cleansed; if deficient, the whole of the fat not being converted into soap, the wool will remain greasy. The same operation may be performed with fixed alkali, as a lye of potash; but besides that this lye is much more expensive than the urine, there is some danger, if you fail in the exact proportion, that it may injure the wool. For I recollect from various experiments that these kind of caustic salts soon destroy all animal substances, as wool, goats' hair, silk, etc.

I must entreat the reader to remember, though I should make no further mention of this operation of scouring, that it is nevertheless necessary for all wool which is to be dyed before it is spun, and even when spun: also stuffs of all kinds, should be soaked, in order to prepare them for receiving the colour more equally.

Of the five primitive colours already mentioned, two of them should be prepared with ingredients that furnish no colour, but which, by their acidity and the fineness of their earth, dispose the pores of the wool to receive the colour. This preparation is called the *bouillon*. It varies in proportion to the nature and shade of the colour. The colours which more particularly require it are the red, the yellow, and the colours derived from them. Black requires a particular preparation. Blue and fawn colour none; it is sufficient that the wool be well scoured and soaked, and even for the blue there is nothing more required than plunging it into the vat, stirring it well, and letting it remain for a longer or shorter time according as you would have the colour more or less deep. This reason,

and the necessity of previously giving wool a tinge for many colours, has determined me to begin with the most exact rules for this colour. Notwithstanding the very great facility of dyeing wool blue, when the blue vat is once prepared, it is far otherwise with regard to the preparation of this vat, which is actually the most difficult operation in the whole art of dyeing. The rest require nothing more than a simple process, transmitted from masters to their apprentices.

There are three ingredients used in blue, viz. pastel, woad, and indigo. I mean to treat of the preparation of each, and shall begin with the pastel vat.

CHAPTER V

Of the Pastel Vat

Pastel is a plant cultivated in Languedoc and in other parts of the kingdom. It is imported in balls, generally weighing from 150 to 200 pounds; and resembles a collection of little lumps of dry earth, intermixed with the fibres of plants. It is called in Latin, *isatis* or *glastum*, which being gathered at a certain degree of maturity is suffered to rot, and then made into balls for drying. Various are the precautions to be observed in this preparation, upon which M. Colbert, in his *Regulations for the Art of Dyeing*, has given several articles. The best prepared pastel comes from the Diocese of Alby.

To extract the blue colour it is necessary to have large wooden vats, such as I have mentioned in the beginning of this work; the larger the better. You generally take three or four balls of the pastel, and having well cleaned the vat, you proceed in the following manner:—

Your copper cauldron should be placed as near as possible to the vat, and then filled with pond water; if the water be not sufficiently putrid you put in a handful of hay, viz. about two or three pounds, with eight pounds of brown madder, or the bark of the root. If you could have the old liquor of a madder vat it would save fresh madder, and have a better effect. When the copper is full the fire should be lighted under it at three o'clock in the morning. It should boil an hour and a quarter; some dyers let it boil two hours and a half

or three hours. It is then, by means of a spout, conveyed into the vat, which should be very clean, and have at the bottom a hatful of wheaten bran. While the boiling liquor is running into the vat, you put in your pastel balls, one after another, in order that they may be more easily broken, mixed, and stirred with the rake. It should indeed be continually stirred till all the hot liquor is emptied out of the copper into the vat, and when the vat is rather better than half-full, it should be covered with a lid, a little larger than the circumference; besides this, there should be a cloth over it, to confine the heat as close as possible, and then it should stand for four hours.

About four hours after the vat is set it should be uncovered, in order to mix it well and to give it air. For every ball of pastel you throw into it a full measure of *ware*, a false name which the dyers give to slaked lime. This measure is a kind of wooden slice, used for measuring the lime into the vat. It is five inches broad, and three and a half long, and contains about a handful of lime. After scattering in the lime the vat should be well mixed and covered as before, except a little space, about the breadth of your hand, to let in the air.

Four hours afterwards it should be stirred again, without supplying it with any more lime, then covered, and suffered to stand for three hours longer, leaving, as before, a small opening to let in the air.

At the expiration of three hours it may be again uncovered and well stirred, and if it be not yet ready, and *come to*, according to the language of the dyers, that is, if the blue does not rise to the surface, and that it still foams, which may be known by striking with the flat of the rake, it will be necessary, after stirring it well, to let it stand an hour and a half longer, watching it carefully during that time, in case it should cast blue. You then supply it with more water, till the vat is full, putting

in as much indigo as you think proper, the dyers at present being at liberty to use as much as they please. Of this solution of indigo, which shall be hereafter explained, they generally allow one common dye-house kettle for every ball of pastel. Having filled the vat within six fingers of the edge, you mix it well and cover it as before.

An hour after it has been supplied with water you give it two measures of lime for every ball of pastel, or in proportion to the quality of the pastel, according as you think it will *use* the lime. The reader will, I hope, pardon these expressions: this treatise being written for dyers, I am therefore obliged to speak their language. The philosopher will have no difficulty in substituting proper terms, which the workmen would probably not understand. Some kind of pastel requiring much less preparation than others, it is therefore impossible to give rules that would be accurate and at the same time general. It is, however, necessary to observe that the lime should not be scattered in till the vat be well stirred.

Having again covered your vat, at the expiration of three hours you put in a pattern, which should remain immersed in the liquor for three hours. You then take it out in order to examine the state of your vat. If ready, your pattern should be green when taken out; but by being exposed to the air should become instantly blue. If it be of a good green you stir the vat, adding one or two more measures of lime and then cover it.

You stir it again, three hours afterwards, adding more lime if necessary. You then cover it for an hour and a half longer, and then the vat being settled you immerse a pattern, which at the expiration of an hour you take out again, in order to see the effect of the pastel. If the pattern be a good green when taken out, and becomes a deep blue by being exposed to the air, you put in another pattern, in order to ascertain the effect

of the vat. If the colour of your pattern be sufficiently high you fill your vat with hot water, or, if possible, with the liquor of an old madder vat, and then stir it again. If you think the vat wants lime you add a sufficient quantity, according to the smell, and as by the working you may find it necessary. This done, you cover it again, and an hour afterwards, if your vat be in a proper state, you immerse your stuffs. This is to *open* the vat, as the dyers call it.

DIRECTIONS FOR THE PROPER MANAGEMENT OF THE VAT

Your vat is ready for working, that is to say, in a proper state for dyeing blue, when the sediment or grounds at the bottom is of a fine brown green; when it changes upon being taken out of the vat; when the froth which rises in great bubbles on the surface is of a fine Persian blue; and when the pattern which had been steeped an hour is of a fine dark grass-green colour.

When in a proper state for working, the liquor will be clear and reddish, and the drops which stick to the rake, brown.

When the sediment or grounds, as I have already said, change colour when taken out of the *brevet* or liquor, and becomes brown when exposed to the open air.

When the liquor is neither harsh nor too greasy to the feel; when it neither smells of lime nor of lixivium. These are as near as possible the marks which denote that your vat is in a proper state for working.

INDICATIONS WHEN A VAT HAS SUFFERED BY TOO MUCH OR TOO LITTLE LIME, THE TWO EXTREMES WHICH OUGHT CAREFULLY TO BE AVOIDED

When a vat is too plentifully supplied, that is, when it has had more lime than the pastel requires, you will easily discern it by putting in a pattern, which instead of becoming a fine grass green is only a dirty greyish blue; when the sediment does not change colour, when there is scarce any efflorescence on the vat, and when the liquor smells only of lime or of the lixivium of lime.

In order to remedy this evil it is necessary to unfurnish the vat, for which purpose the dyers have several methods. Some use tartar, others bran, adding a bushel of either, more or less, according as the vat may require. Others throw in a bucket of urine. In some places they use a large iron stove, long enough to reach from the grounds at the bottom to the top of the vat. This machine has a grate within a foot of its bottom, and an iron funnel commencing with the bottom of the grate and communicating with the external air. This furnace is plunged into the vat as far as the grounds, without forcing it down, and should be retained by iron bars to prevent its rising. The heat communicated by this stove causes the lime at the bottom of the vat to rise to the surface; by this means you can easily take out as much of it as you think proper with a sieve. But when you have taken it out you should be careful to re-supply the vat with a sufficient quantity.

Some dyers correct a pastel vat with tartar and stale urine boiled together; but the best method is to put into it a sufficient quantity of bran and madder, and if the excess of lime be not great you may let it stand four, five, or six hours, or more, only adding to it two hatfuls of bran and three or four pounds

of madder, which should be sprinkled lightly on the top; it should then be covered. At the expiration of four or five hours you stir it with the rake and then put in a pattern in order to try the effect.

If it be checked, and that the blue does not rise until it be cold, you should leave it to recover, without disturbing the liquor, and sometimes let it stand for whole days without mixing. As soon as it gives you a tolerable pattern it should be reheated. In general the lime, which seemed to want strength sufficient to promote fermentation, revives, and prevents the vat for some time from yielding any colour. If you would bring it forward you should sprinkle some bran and madder on the top, besides an addition of two basketfuls of fresh pastel, which assists the liquor when reheated in dissolving the lime.

You should now try the vat by putting in a pattern from hour to hour, that you may be enabled to judge by the colour of the green how far the lime has operated. By these experiments you will be directed to conduct it with accuracy, for when the vat has suffered by too much or too little lime it is extremely difficult to manage. If during the time you are endeavouring to retrieve it the liquor should cool too fast, you should preserve the heat by emptying out some of the liquor and replacing it with hot water; for when the *brevet* or liquor grows cold the pastel consumes none, or but very little, of the lime. An over-degree of heat will also retard the action of the lime. In this case therefore it were better to wait a little rather than be in too great a hurry to restore the vats when they have suffered.

It is evident that the vat has suffered by not being sufficiently supplied with lime when there is no efflorescence on the liquor, viz. no large air-bubbles of a fine blue colour, only a settled froth of small tarnished bubbles, and when by dashing

it on the surface with the rake it makes a hissing noise, produced by the bursting of an infinite number of these small air-bubbles as soon as they are formed. The liquor has also an offensive smell like rotten eggs. It is harsh and dry to the feel, and the sediment does not change colour when taken out of the liquor. This accident is chiefly to be apprehended when the *overture* is made, and you begin to work; for if you do not carefully attend to the state of the vat by the smell when you stir it, after fixing in the cross or net, and imprudently put in the stuffs, when the pastel has spent the lime it is to be feared that the vat will be spoiled; because if you put in the stuffs when the small quantity of lime remaining is in a state to act, it will stick to them; the liquor becomes impoverished and the vat only blots the stuffs. You should therefore take them out immediately, and replenish as quick as possible, in order to save the remainder of the dye, by adding three or four measures of lime, more or less, in proportion as the vat has suffered, and this without stirring at the bottom. When you stir the vat you should attend to the noise, for if the hissing ceases and the bad smell changes, it is to be hoped that the liquor only has suffered, and that the paste is not yet impoverished. When you have stopped the noise or hissing, at least in part, and that the *brevet* or liquor smells of lime, and is soft to the feel, you cover the vat and let it stand. If at the expiration of an hour and a half the efflorescence commences, you put in a pattern, which in an hour afterwards you take out, and regulate your process according to the degree of green which your pattern has imbibed. But in general, when vats are thus checked, they do not so soon recover.

The vat being in a proper state, you suspend the cross, and begin with thirty ells of cloth, or of scoured wool of equal weight, which you design to prepare for black by first dyeing it a blue grey. Having passed and repassed this quantity,

keeping it in the liquor during a full half-hour, you wind it round the reel which rests on the posts fixed over the vat. The cloth is then hung by the liftings, in order, by exposing it to the air, to change the colour from green to blue. If it be not sufficiently deep for a blue grey after the first turn, you give it another, putting in the end that came first out of the vat, foremost. You give this batch two or three turns, according to the strength of your pastel, and according to the depth of the colour required. If your pastel be good, as the true *lauragais* generally is, you may put into this *overture* or first working a second batch, after the first is taken out.

Having made this *overture*, which is likewise called the first stirring, you stir the vat afresh, adding lime, but not so much as to destroy the above-mentioned feel and smell, observing that in proportion as the colour becomes weaker the virtue of the pastel is also diminished.

If your vat be in a proper state you should, on the first day of working, stir it three or four times. You must be careful not to overwork it, particularly on the second day.

Concerning the colours; to obtain from this fresh vat all possible advantage, you first dye your stuffs designed for black, afterwards the *blues de roy*, and then such as are intended for a brown green. The violet and turkey blues are generally performed in the last stirring on the second day of the *overture*.

If the quantity be too much diminished, on the third day the vat should be filled within four inches of the edge with hot water.

Towards the latter end of the week you dye the light blues, and on Saturday night, in order to preserve it until Monday, you *garnish* with a little more lime than on the day preceding. On Monday morning you reheat, letting the liquor run from the vat into the copper cauldron by means of a spout or channel

placed from one to the other. The clear liquor runs off until it comes to the sediment or paste, and when boiling is returned into the vat, stirring the paste as the liquor falls on it. You may at the same time add a full cauldron of prepared indigo, as shall be hereafter mentioned.

When the vat is within four inches full, and well stirred, you cover it, and at the expiration of two hours put in a pattern, which should remain for an hour only. You then add lime according to the green shade of the pattern, and at the expiration of an hour or two, if your vat has not suffered, you may venture to put in a batch of stuff. This stuff having been washed in two waters for the space of a full half-hour, it is wrung; it should then have another dip, as directed, in a fresh vat. This reheated vat should be conducted in the same manner as at first, that is to say, stirred three times the first day, examining each time, lest it should require more lime, in which case you add the quantity requisite, according to your judgment.

The blue dye of the pastel only is, in the opinion of those prejudiced in favour of old customs, much superior to that obtained from the pastel and indigo together; but then it is more expensive, because the pastel yields much less colour than this foreign drug, repeated experiments sufficiently demonstrating that four pounds of the fine indigo of *guatimalo*, yields as much as a ball of the *albigois* [1] pastel; and five pounds as much as a ball of that of the *lauragais*, which generally weighs 210 pounds. Hence the use of indigo mixed with pastel is very frugal, as a single vat, with the addition of indigo, will dye as much stuff as two vats were the indigo omitted.

They commonly put dissolved indigo to fresh vats after the pastel appears blue, and a quarter, or half a quarter of

[1] That made in Alby.

an hour afterwards, you give it the *pied*, viz. an addition of lime; but as the dissolved indigo is already *garnished* by the lixivium in which it was dissolved, it requires less lime than when the pastel is alone.

When you reheat, the indigo is put in on the Saturday night, that it may incorporate with the liquor, and at the same time serve to *garnish* it by means of its lime.

THE PREPARATIONS OF INDIGO FOR THE PASTEL VAT

The indigo *Guatimalo*, or of *Guatimala*, is the best; it is brought from America in the form of small flint stones, of a deep blue colour. Its goodness is determined by its effect, and also by breaking. If good it will be of a dark violet colour at the inside, and by rubbing it on the nail it will appear copperous. That which is the least ponderous is the best.

In order to dissolve the indigo you must have in your dye-house a separate cauldron and furnace. Eighty or a hundred pounds of indigo require a cauldron containing thirty or thirty-five buckets of hard water.

This should be made into lixivium, by putting five-and-twenty buckets of clear water into the copper, with the addition of a hatful of bran, twelve or thirteen pounds of madder, and forty pounds of good potash; that is, half a pound of alkaline salt, and two ounces and a half of madder to each pound of indigo, these quantities being necessary for the solution of eighty pounds of this drug. It should boil fast for three-quarters of an hour, or thereabouts; the fire should then be taken from under the furnace, and the lixivium should stand during half an hour, in order that the lees or dregs may fall to the bottom. The clear liquor is then poured into a clean cask placed close to the copper. Take out the grounds at the bottom of the copper, wash it clean; return the clear lixivium into

the copper; light a small fire under it, and at the same time put into the copper eighty pounds of indigo, reduced to a gross powder. The liquor should be made very hot, but not suffered to boil; and to facilitate the solution you keep continually stirring it with a small rake, to prevent it from gathering into lumps or from burning to the bottom of the copper. You should keep the liquor moderately hot, and the degree of heat as equal as possible, by throwing into it from time to time some lixivium of lime, which should be at hand ready prepared, in order to cool it. As soon as you perceive that there is no longer any lumps in the bottom of the copper, and that the indigo is well dissolved and diluted, you draw the fire from the furnace, leaving only a few hot cinders to keep it warm; you cover the copper, and then put in a pattern of stuff which should be green when taken out, and turn blue immediately upon being exposed to the air. If this should not be the case you must add some fresh clear lixivium, prepared in the same manner as the preceding. Of this solution of indigo, one, two, or more buckets are added to the pastel vat, when it has sufficiently fermented and begins to yield its colour. This part of the art of dyeing requires an able workman.

Having convinced myself of the methods necessary for the success of a large pastel vat, I determined also to try if it was not possible to set one on a much smaller plan, by some dyers supposed to be impracticable. I took a little barrel, containing about five-and-twenty gallons; this I put into a copper full of water, which I carefully kept properly heated. I then put into a small copper twenty gallons of water, with an ounce and a half of madder and a very small handful of dyers' weed, an herb used for dyeing yellow, but which upon the whole seems to be of no use in this operation; I was, however, advised to use it, as being necessary. I let them boil together for three full hours, and about nine o'clock in the

evening poured all this liquor into the barrel, which stood in the copper, having first put in two small handfuls of bran. I added at the same time four pounds of pastel, and having stirred it well for a quarter of an hour, covered it, and took care to have it stirred in the same manner every three hours, even during the night. I put no sour water into this little vat, as is the custom at present; but the bran which I had just put in served as a substitute, because it soured with the liquor.

The next morning about nine o'clock the vat began to make a little noise or hissing. It also formed a kind of froth like suds. Having mixed it well I added an ounce and a half of slaked lime, sifted, which increased the froth. The smell became stronger, and therefore I was of opinion that a little more pastel might be added.

At half-past ten the vat smelt stronger of the lime, produced froth, and made a little noise. I immediately put in a pattern, which at the expiration of an hour I took out green, and which upon being exposed to the air became blue. I stirred it again, and an hour afterwards put in another pattern, which after remaining an hour also came out green like the first, but upon being exposed to the air was of a deeper blue. By this I concluded it was in a proper state for the indigo.

At half-past twelve I added two ounces of indigo, not dissolved, only pounded, sifted, and diluted in warm water, with a lump of *cendres gravelées* as big as a walnut (that is, the lees of wine calcined, which as I have already said contains a quantity of alkaline fat). Every two hours afterwards I put in a pattern, alternately stirring, that is to say, an hour after I stirred the vat I put in the pattern, which remained another hour, after which I again stirred, and so on until ten o'clock. Upon comparing the patterns the last was always evidently

the darkest: they also became more and more bright, in proportion as the lime was consumed.

It ought now to have been replenished, because the last pattern showed that the lime was exhausted. In that case it would have been necessary to have worked at it until two o'clock in the morning; and therefore being an inconvenient time, I chose to defer *garnishing*, giving it only sufficient to sustain it until the next day; that is to say, about half an ounce of lime, to stir it, and an hour afterwards to put in another pattern, which at the expiration of an hour was in fact more blue than the others, but which on account of the lime was less lively than the preceding. In this manner the vat may be retarded or brought into a proper state, as most convenient.

Two more patterns were put in during the night, which were still darker. That which was taken out at eight o'clock in the morning being a little dull, showed that the lime which had been put in the preceding evening was not yet consumed. Some of the paste which I had taken from the bottom with a rake, in order to examine the state of the vat, was of a yellowish brown, but when exposed to the air became of an olive green. It appeared of the same colour under the surface if moved with the hand, but instantly became green. It smelt rather strong, though not so much of the lime. The liquor was something of the colour of beer, and the scum or froth produced by stirring it with the rake was blue. By these signs you are best enabled to judge of the state of your vat.

I still continued to put in patterns and to stir alternately until two o'clock in the morning. The pattern then taken out was of a very fine green, and immediately afterwards became of a beautiful blue, which showed that it was time to fill the vat. For this purpose I put about eight gallons of

water into a little copper, with a quarter of an ounce of madder and a handful of bran; when it had boiled half an hour I put the liquor into the little vat for three hours. It was then stirred, and an hour afterwards a pattern put in, which at the expiration of an hour was taken out very beautiful and lively.

This little vat was ready for working at seven o'clock, and might have been ready seventeen or eighteen hours sooner, but was designedly retarded. The cross or net, such as I have already described when speaking of the necessary utensils for dyeing, was let down within three or four fingers of the paste or grounds, and suspended by means of four pack-threads fastened to the edge of the cask.

An ell of serge was then immersed, without any other preparation than having been previously wet, in order to make it imbibe the colour equally. It was then moved with the hand and a little iron hook for about a quarter of an hour, at the expiration of which time it was taken out very green. It was then wrung or pressed, and immediately upon being exposed to the air became blue. It was again put into the vat for a quarter of an hour more, in order to give it a deeper colour, when it was taken out much greener than the first, and upon being again wrung, became a more beautiful blue than I could have expected.

A pound of worsted was then immersed, having been previously wet with hot water and expressed; but the vat retained so little of the pastel that the worsted imbibed only a sky-blue colour. It was again immersed the day after, for the last time; and to preserve the vat, and at the same time to restore the colour, I sprinkled into it half an ounce of sifted lime. Before this it smelt something like roast meat; but immediately upon throwing in the lime there arose a volatile alkaline or urinous odour. The vat was then covered, and

the next day the worsted was finished. It was still possible, by replenishing the vat to dye a pound or two more; but not to lose time I had it thrown out, these experiments being sufficient to demonstrate the possibility of setting a pastel vat *in the little* as well as *in the great.*

I shall however add some necessary reflections, in order to convey a more perfect idea of this operation.

A pastel vat should never be reheated, but when fit for working, that is to say, when it has neither too much nor too little lime, and requires heat only to be in a proper state. When it has too much lime it smells offensively. On the contrary, if it smells sweetish, and that the froth which rises on the surface when stirred with the rake is of a pale blue, the quantity of lime is not sufficient.

When you would reheat you should be careful not to *garnish* with lime over night (I mean if it should not require it very much), as you would by so doing run a risk of giving it the *coup de pied,* or *kick,* as the dyers term it; for the lime which the vat had retained, by reheating acquires more action, and is too quickly consumed.

You generally put fresh indigo into the vat as often as it is reheated, and that in proportion to your quantity of work; but if you have not much work, and require only light colours, this addition is unnecessary.

The ancient *Regulations* allowed only six pounds of indigo to every ball of pastel, imagining that the colour obtained from the indigo was not solid, and that to constitute a permanent colour it was necessary to add a great quantity of pastel; but from the late M. Dufay's experiments, and from those which I have myself since made, it is at present fully proved that the colour of the indigo, even without any addition, is equally good, and as little affected by the air, the sun, rain, or boiling, as the pastel. This article therefore was reformed

in the new *Regulations* of 1737, where the dyers in grain are permitted to use as much indigo as they please.

When a vat has been heated and well worked two or three times, the same liquor is frequently preserved, only taking out a part of the sediment and replacing it with some fresh pastel. It is impossible to ascertain the quantity, as that must depend on the work to be done, and this proportion will be soon learnt by experience. Some dyers preserve the same liquor in their vats for several years, replenishing only with pastel and indigo in proportion as it has been worked; others empty their vat entirely, changing the liquor when it has been reheated six or seven times, and that it no longer yields any colour. Practice only can ascertain which is the best method. It is however rational to suppose that by entirely renewing the vat from time to time, the colours will be more lively and much finer. Those who practise the contrary method are not the best dyers.

Their vats in Holland are of a different construction, and do not require such frequent heating. They have been used for many years in Messrs. Van Robbais' royal manufactory at Abbeville. The upper three feet of these vats is made of copper. They are mostly surrounded by a brick wall about seven or eight inches from the copper. In this interval the embers are deposited, which maintain the heat of the vat for a considerable time, so that it remains for several days in a proper state for working, without the necessity of reheating. These vats are much more expensive than the others, but they are more convenient, especially for light colours, because they are always ready for working, even after they become very weak. This is never the case with the others, which frequently give a much deeper colour than was intended, unless you suffer them to grow considerably colder, and then the colour is neither so good nor so lively. In order to dye

these light colours in the common vats, it were better to prepare one on purpose, that should be strong in pastel and weak in indigo, because these would give their colour more slowly, and the light colours be obtained from them with much more facility.

With regard to the Dutch vats just mentioned, the four constructed by the direction of Messrs. Van Robbais in their manufactory, are six feet deep, the upper three feet and a half copper, and the lower two feet and a half lead. The diameter of the bottom four feet and a half, and of the top five feet four inches.

I now return to the necessary observations on reheating the common vats. If you heat a vat when exhausted, viz. when it is deficient in lime, it will turn imperceptibly in such a manner as to be in danger of being spoiled, because the lime, already too much diminshed, will be entirely consumed by the heat. The only remedy, if discovered in time, is to throw it back into the vat and to replenish with lime. You should then wait until it recovers before you reheat.

When reheating you should be careful to put the grounds into the copper with the liquor. You should also be very careful not to let it boil, else the volatile parts necessary towards the operation will evaporate. Some dyers do not put indigo immediately after the liquor is emptied out of the copper into the vat; not until some hours afterwards, when they perceive the vat begin to retrieve. This precaution is taken lest the vat should not recover, in which case the indigo would be lost. But then it does not give its colour so freely; for being obliged to work at the vat immediately, lest it should cool, the indigo, not being sufficiently dissolved or entirely incorporated, does not produce its full effect. It were therefore best to put the indigo into the vat immediately with the liquor, and to stir it well afterwards.

When you reheat a vat that has not been worked it should not be skimmed, as in the common reheatings, because you would then take out the indigo; whereas in a vat that has been worked the skim is formed of the earthy particles of the indigo and pastel joined to a portion of the lime.

When you have put too much lime into the vat, you must wait until it be consumed. It might be accelerated in the reheating by the addition of ingredients which would in some degree destroy the action of the lime, such as tartar, vinegar, honey, bran, a mineral acid, or in short any acid matter. But these correctives would, at the same time, consume the colour of the indigo and pastel. It were therefore best to let the lime consume, without using any method to promote it.

Vats are generally not *garnished* with lime until the second or sometimes the third day, and therefore you should by no means immerse the violets, the purples, or any of the delicate coloured worsted or stuffs on the day after you had replenished, because the lime, being yet tolerably active, tarnishes the first colour: it should therefore be the fifth or sixth day before you put in your crimsons for violets, or your yellows for green. By attending to this particular your colour will be always bright.

When the vat has been reheated you must wait until it begins to work before you *garnish*. If it be done too soon it will become turbid, or if a little of the paste is put into the copper it is attended with the same consequence. In this case your remedy is to let it stand until it settles before you begin to work, which will require two, three, or four hours, or even a whole day.

You sometimes make use of weak lime; but then if you do not take care your vat gets a kick, because this lime remains

in the liquor and does not incorporate so well with the paste. When this accident happens the liquor has a strong smell, and the paste on the contrary a sweetish smell, whereas they should both smell alike. Your remedy is to hasten the solution by stirring it often in order to mix the lime with the paste, until the proper smell of the vat be restored, and until the froth or skim becomes blue.

You may, if you please, set a pastel vat without indigo; but then it would yield very little colour, and dye but a very small quantity of stuff or wool; for one pound of indigo, as I have already said, yields as much colour as fifteen or sixteen pounds of pastel. I had one of these kind prepared, in order to ascertain the power of the pastel alone, and I have found, notwithstanding what prejudice may urge to the contrary, that the indigo is in no respect inferior in the beauty and solidity of its colour.

As lime is constantly used in setting a vat, and sometimes sour water, I think it is proper in this place to mention their preparation.

In order to slake lime fit for dyeing, you throw into water several pieces, one after another, taking out each piece when it begins to ferment, and putting in another. It is then thrown into a copper or any other empty vessel, where it will fall to powder and considerably increase in bulk. It is afterwards sifted through a canvas bag, and preserved in a very dry cask or tub.

Acid waters are necessary not only in particular circumstances relative to the setting of a pastel vat, but also in some preparations of woollens and stuffs for dyeing. They are made in the following manner:—

Fill a copper of any size with river water, put fire under it, and when it boils throw it into a cask in which you had before put a sufficient quantity of bran. It should be well

stirred three or four times a day. The proportion of bran or water is not very important. For my part, I found that putting three bushels of bran into a vessel containing seventy gallons of water had the desired effect. This water, at the expiration of four or five days becomes sour, and consequently proper to be applied in all cases where it does not injure the preparation of the worsted.

Woollen fleece dyed in liquor containing too great a quantity of acid water would in all probability be difficult to spin, as the fibres of the wool being glued by the bran would not produce an even thread. It is also necessary to observe that it is a bad custom to leave the acid water to remain in the copper cauldron, as I have seen practised by some eminent dyers: as it will corrode the copper, and if suffered to remain long enough to dissolve any part of this metal, it will occasion a defect both in the colour and stuff; in the colour because the dissolved copper gives a greenish tinge; in the quality of the stuff because it acts as a corrosive on all animal substances.

To the best of my knowledge I have omitted nothing essential concerning the pastel vat. If any difficulties should occur in the practice, or any accident happen which I have not mentioned, they are not very considerable, and may be easily remedied by those who are acquainted with this operation. Readers having no idea of this process will suppose me tedious, they will also find many repetitions, but those who read this chapter for the sake of instruction will perhaps blame me for being too concise. I thought it more necessary, on account of the difficulty of the operation, to put the observations I had made, from my own experience, concerning the government of the small vat, in the form of a memoir, describing it as I have, hour by hour, rather than dwell on the description of preparing a vat in the *great* as above described, because I

was not always on the spot. Those who have read this chapter with attention will not be surprised that the masterpiece expected from apprentices who would be admitted as master dyers, either in grain or not in grain, is the preparation, and more especially the working, of the pastel vat.

CHAPTER VI

Of the Woad Vat

There is scarce any difference to be observed with regard to the woad and pastel vat. The woad is a plant cultivated in Normandy, and prepared almost in the same manner as the pastel in Languedoc. As to the cultivation of these I must refer the reader to the general instructions for dyeing of the 18th of March 1671, from the article 259 to the article 288, inclusive. The woad vat is prepared in the same manner as the pastel vat; it differs only in being weaker and yielding less colour. The following is a description of the woad vat, according to an experiment which I made in miniature, similar to that concerning the pastel in the preceding chapter. My object was to verify a process an account of which was sent me from Normandy.

I placed in a cauldron a small cask, containing about twelve gallons, two-thirds full of river water, an ounce of madder, and a small quantity of weld. At the same time I put into the cask a good handful of bran and five pounds of woad. At five o'clock in the evening the vat was well stirred and covered. It was again stirred at seven, at nine, at twelve, at two, and at four. The woad was then working, as I have already observed with regard to the pastel. Some air-bubbles began to rise pretty large, but in a small quantity and of a very faint colour. It was then garnished with two ounces of lime, and stirred. At five o'clock I put in a pattern which I took

out at six, and again stirred. This pattern had received some colour. At seven o'clock I put in another, and at eight stirred again. This pattern was tolerably bright. I then added an ounce of indigo. At nine o'clock another pattern; at ten stirred again, and put in an ounce of lime, because it began to smell sweetish. At eleven another pattern, and at twelve stirred again. This process was continued until five o'clock. I then added three ounces of indigo. At six I tried another pattern, and at seven stirred again. It would have been now time to fill it, being in a proper state for working, as the last pattern which had been taken out very green became a bright blue. But as I was very much fatigued, having sat up the whole night, I chose to defer it until the next day, in order to see its effect by daylight, and for this reason I added an ounce of lime, sufficient to sustain it until nine o'clock in the morning. Patterns were put in from time to time, and the last being very beautiful I filled the vat with a liquor composed of water and a small handful of bran only. It was then stirred, and patterns tried every hour. Being in a proper state at five o'clock it was immediately worked. It was then garnished with lime and mixed, in order to preserve it until such times as it might be convenient to reheat.

Two months afterwards I prepared another woad vat, without indigo, that I might be enabled to judge of the solidity of the dye, and was convinced by experiment that it was of equal goodness with the pastel. Hence the pastel is superior to the woad only because the latter yields less colour than the other.

The little variations to be observed in the method of setting these different vats, sufficiently demonstrates that there are many circumstances in the several processes not absolutely necessary. In my opinion the only matter of importance, and which demands attention, is to conduct the fermentation with caution, and to avoid supplying with lime until, from the

indications I have described, it appears necessary. With regard to the indigo, whether it be added at twice or all at once, whether a little sooner or a little later, is, I think, of very little importance. The same may be said of the weld, which I used twice, and twice omitted, and likewise of the pearl-ash, a little of which I put into the small pastel vat, and omitted in that of the woad. In short it appears to me very demonstrable that the distribution of the lime, either in the setting or re-heating the vats, requires most attention. It must also be observed that in setting either a pastel or woad vat, it cannot be too frequently examined, because though some are too slow, which is attributed to the weakness of the pastel or woad, others become too soon ready for working. I have seen seventy pounds of pastel lost by this neglect. It was ready for working at eight o'clock, but for want of the workman's constant inspection he did not discover it until two hours afterwards. The paste was then entirely risen to the surface of the liquor, which smelt very sour. It was now impossible to recover it; he was therefore obliged to throw it out immediately, or it would very soon become insupportably putrid and fœtid.

This difference in the vat may be also produced by the temperature of the air, as it cools much sooner in winter than in summer. It is therefore necessary to watch very attentively, though it is seldom fit for working in less than fourteen or fifteen hours. I shall endeavour to explain hereafter the method of developing the colouring particles of this ingredient; but I must first speak of the vats prepared with indigo only.

CHAPTER VII

Of the Indigo Vat

Indigo is the dreg, or rather the inspissated ice of a plant called *nil* or *anil*. In order to produce this substance you must have three tubs, one over another, resembling a cascade. The first, called the *soaking* or *rotting* tub, you fill with water and put into it the plant, with the leaves, bark, and flowers. At the expiration of some time the water begins to heat and bubble, grows thick, and becomes of a violet colour. It is the opinion of some that the plant deposits all its salts, and of others all its substance. You then turn the cock of the *soaking* tub, and let the water, impregnated with the whole colouring substance of the plant, run into the second tub, called the *beater*, because in this the water is beaten with a kind of battering mill, in order to condense the substance of the indigo, which is thereby precipitated so entirely that the water loses all colour and becomes clear as common water. The cock is then turned, that the water may run off until it comes to the surface of the blue dregs; the lowest cock is then turned, that the whole substance may run into the third tub, called the *repository*, because in this tub the indigo remains to dry. It is then taken out and moulded into cakes or tablets, etc. (see P. Labat, *Hist. of the Antilles*).

On the coast of Coromandel, at Pondicherry, etc., there are two sorts of indigo, one much finer than the other; the fine sort is used only for giving gloss to the colour, and the inferior

sort for dyeing. There are, besides, several other sorts, which augment in price according to their quality. You may meet with some from fifteen pagodas the bar, weighing forty-eight pounds, to 200 pagodas. The finest is prepared on the coast of Agra. It is also made pretty good at Masulipatam, at Ayanaon, where the India Company had a settlement. At Chandernagor they call it *nil* when prepared and cut into pieces. The best of all is the *Java* or the *Javan* indigo; but it is also the dearest, consequently not much used by the dyers. The best indigo should be light, so as to float on the water; the more it sinks the greater the probability of its being mixed with earth, ashes, or pounded slate. It should be of a dark blue colour, almost violet, bright and sparkling, particularly when broken. You may try it by dissolving a bit of it in a glass of water. If pure and well prepared, it will dissolve entirely; but if adulterated, the matter will sink to the bottom of the vessel. The second method of ascertaining its goodness is by fire; for the indigo will entirely consume, but the extraneous particles will remain, even after it is burnt. The pounded indigo is much more liable to adulteration than the tablets, because it being difficult for the sand and pounded slate to adhere, it runs into different strata; but this, by breaking a bit of the indigo, is easily discernible.

There are several methods of preparing an indigo vat, which are all in some respects different from each other. I have tried as many ways as came within my knowledge, and succeeded in almost all of them. I will describe them as precisely as I can, beginning with that most generally in use, and which is almost the only one known at Paris.

I gave at the commencement of this work a description of the copper vessel necessary for this preparation. To assist the recollection however, I will just mention that this vat is about five feet high, that it is two feet in diameter, and that

it grows narrower towards the bottom; that it is surrounded by a wall, leaving a vacancy for the embers. In a vat of this size you may put from two to five or six pounds of indigo. In order to set a vat containing twenty gallons, you boil in a copper about fifteen gallons of river water for half an hour, with two pounds of potash, two ounces of madder, and a handful of bran. The indigo is prepared, meanwhile, in the following manner:—

Take two pounds of indigo and put it into a pail of cold water, in order to separate the solid from the volatile particles, which will immediately rise to the surface. The water is then poured off, and the remaining indigo pounded in an iron mortar; you then put a little hot water into the mortar, shaking it from side to side, and pouring into another vessel that which swims, and which is consequently the best bruised. In this manner you continue to pound what remains in the mortar, still adding fresh water, in order to make the finest part rise to the surface, and so on until all the indigo is reduced to a powder so fine as to rise in the water, which is all the preparation required. The liquor which had boiled in the copper, with the grounds of the madder and potash, which probably fell to the bottom, is thrown into the high, narrow vat, at the same time adding the pounded indigo. The whole is then well stirred with a rake, the vat covered, and the embers put round it. If this operation was begun in the afternoon you must renew the hot embers in the evening, which should also be repeated both morning and evening the next day. The vat should be lightly stirred twice the second day. In order to maintain the heat of the vat you renew the embers on the third day, stirring the vat twice. You then perceive that a shining, brassy scum, divided and interrupted in many places, begins to rise on the surface. By continuing the heat on the fourth day the scum becomes more perfect and less

broken. The froth that rises upon stirring is now blue, and the vat a deep green.

When it becomes green in this manner it is an indication that the vat should be filled. For this purpose you must prepare a fresh liquor by putting five gallons of water into a copper, a pound of potash, and half an ounce of madder. When this has boiled a quarter of an hour you fill the vat. You then stir it, and if it produces much froth it will be in a proper state for working the next day. This is sufficiently known by the quantity of froth, and by the brassy, scaly crust that swims on the top of the liquor; also, and when by blowing or stirring it with the hand the liquor beneath is green, though the surface appears of a brown blue.

This vat, of which I have just described the process, and the first I had set, was much longer in coming to a colour than the others, because the heat was too strong the second day; but for this accident it would have been ready for working two days sooner. It was attended with no other bad consequence, and therefore as soon as it was in a proper state for working, I dipped, at several times, thirty or forty pounds of serge. As the liquor was by this means diminished and weakened, it was necessary in the afternoon to replenish with a fresh mixture, composed of a pound of potash, half an ounce of madder, and a handful of bran. Having boiled this a quarter of an hour it was put into the vat, which was then stirred, covered, and a few embers put round it. In this manner it may be kept for many days; but when you mean to work it, it should be stirred the preceding evening, and supplied with hot embers.

When you would reheat this kind of vat and replenish it with indigo, you put into a copper two-thirds of the liquor, now no longer green, but of a brown blue and almost black. When it is ready to boil the scum on the top should be taken

off with a sieve, after which it should be suffered to boil, with the addition of two handfuls of bran, a quarter of a pound of madder, and two pounds of potash. The embers are then taken from under the copper, and a little cold water thrown in to stop the boiling. It is then emptied into the vat, with the addition of a pound of indigo, pulverised and dissolved in some of the liquor, as I have said above. The vat being then stirred, covered, and a few hot embers put round it, will be fit for working the next day.

When an indigo vat has been reheated several times, it should be emptied out entirely and set anew, because the colour becomes dull; for though heated, and in a proper state for working, the green colour is not so beautiful as at the beginning.

I have had several other vats set in the same manner, with a greater or less quantity of indigo; as from one to six pounds, proportionately increasing or diminishing the other ingredients, always however putting a pound of potash to a pound of indigo. From other experiments which I have since made I am convinced that this proportion was not absolutely necessary. I am also persuaded that there are many other methods for the preparation of the indigo vat equally effectual. I shall nevertheless make some observations concerning this vat.

Of all those which I have had prepared in this manner I failed but in one, which was occasioned by neglecting to put hot embers round it on the second day. I added some pulverised arsenic, but without any effect; it would never come to a colour. Red-hot bricks were also thrown into it at several times; the liquor at times became greenish, but never sufficiently. At length, after having to no purpose tried several other means, without being able to discover why it did not succeed, and having reheated it several times, I had it thrown out at the fortnight's end.

The several other accidents which I met with in the conduct of the indigo vat only retarded the success; so that this operation may be considered as very easy in comparison of the pastel or woad vat. I have indeed made several experiments on each of them, with an intent to shorten the time of the preparation; but for the most part not succeeding, or at least not better than by common practice, it is needless to describe them.

The liquor of the indigo vat is not in every respect like that of the pastel. Its surface is a brown blue, covered with coppery scales, and the liquor itself of a fine green. The stuff or woollen which it dyes is green when taken out, and becomes blue immediately afterwards. The same observation has been made with regard to the pastel vat, but it is very singular that the liquor of the latter is not green, though it produces the same effect upon woollen as the other. It is also necessary to observe that when the liquor of the indigo vat is changed out of the vessel and too long exposed to the air, it loses its green colour, and at the same time all its qualities; so that though it yields a blue colour it is not permanent. I shall examine this more particularly hereafter, when I shall endeavour to account chemically for this alteration.

CHAPTER VIII

Of the Cold Indigo Vat with Urine

There is likewise a cold preparation of an indigo vat with urine, and it is also worked cold. For this purpose you take four pounds of indigo powdered, and put it into a gallon of vinegar, leaving it to digest over a slow fire for four-and-twenty hours. At the expiration of this time, if it be not perfectly dissolved, it is again pounded in a mortar with the liquor, adding now and then a little urine. You afterwards put into it half a pound of madder, mixing it well by stirring the whole with a stick. When this preparation is finished, you pour it into a cask containing sixty gallons of urine; it is of no consequence whether it be stale or fresh. You mix and stir the whole well together; and this should be repeated morning and evening during the space of eight days, or until the surface of the liquor becomes green when stirred, and produces froth like the common vats. It may be worked immediately without any other preparation than stirring it three or four hours beforehand. This kind of vat is extremely convenient, because when it is once prepared it remains so always, till it is entirely exhausted, that is to say, till the indigo has yielded all its colour; hence it may be worked at all times, whereas a common vat must be prepared over night.

According as you would have this vat more or less considerable, you augment or diminish the ingredients in pro-

portion to your quantity of indigo; thus for every pound of indigo you always put a quart of vinegar, two ounces of madder, and fifteen gallons of urine. This vat is much sooner prepared in summer than in winter. If you would hasten it you need only take a little of the liquor, heat it in a copper, without suffering it to boil, and afterwards pour it into the vat. This operation is so very simple that it is almost impossible it should fail.

When the indigo is entirely exhausted the vat may be renewed by dissolving some fresh indigo in vinegar; but you must add madder in proportion to the quantity of indigo, and then pour it into a vat, which should be stirred as at first, morning and evening: it will be as good as if it were fresh. This however should not be repeated more than four or five times, because the grounds of the madder and indigo would tarnish the liquor, which would consequently render the colour less bright. I must, however, confess that as I have not myself experienced this vat, I cannot answer for its success. But the following, with urine, which I have seen prepared, dyes woollens a very permanent blue.

A HOT INDIGO VAT WITH URINE

A pound of indigo was first steeped in a gallon of urine for twenty-four hours; it was afterwards ground in a large iron mortar with the same urine. When by this means the urine became very blue, it was strained through a fine sieve into a small tub; but the indigo which remained in the sieve was beaten again in the mortar with another gallon of fresh urine, and this was repeated till all the indigo passed through the sieve with the urine. This operation, which continued two hours, being finished, about four o'clock in the evening sixty-two gallons of urine was put into a copper,

which was made very hot, but without boiling; and the scum which rose on the surface of the urine was brushed off the copper with a besom. This was frequently repeated until nothing rose but a slight white scum. The urine being thus sufficiently purified and ready to boil, it was thrown into the wooden vat; the prepared indigo was then added, and the vat stirred with a rake in order that the indigo should incorporate with the urine. Immediately afterwards a mixture, consisting of a gallon of urine, a pound of alum, and a pound of red tartar, was added to the vat; but these were first reduced to a fine powder. The urine was then poured on it in the mortar and mixed together, until it ceased to ferment. It was then poured into the vat, well stirred, and covered; in this situation it was left all night. The next morning the liquor was very green. This showed that the vat was in a proper state, and that it might have been used; but it was suffered to remain without working, because all that had been hitherto done was only the first preparation of the vat, and the indigo which had been put into it was designed only to nourish and temper the urine. Hence the vat was suffered to rest two days in order to complete the preparation, but covered all the time, to prevent it from cooling too fast; it was then managed as follows:—A second pound of indigo was beaten with purified urine, as above; about four o'clock in the afternoon the whole vat was emptied into the copper. It was then made very hot, but not boiled. It still produced a thick scum, which was taken off, and the liquor, being near boiling, was returned into the vat. The indigo was immediately added, bruised as above, with a pound of alum, a pound of tartar, and two quarts of urine, with the addition of another pound of madder. It was then stirred, close covered, and suffered to remain so all night. The next morning it was in very good order, the liquor being very hot, and of a beautiful green;

hence it was evidently in a proper state for dyeing, which was executed in the following manner. The substance to be dyed was woollen fleece.

This fleece had been well scoured with urine, well washed, and perfectly well drained. Being thus prepared, thirty pounds of it was put into the vat. It was then well opened with the hands, that it might be equally drenched ; and after this it was suffered to remain an hour or two, according to the degree of shade that was required. During this time the vat was kept close covered, in order to preserve the heat, for the hotter it is the better it dyes : when it becomes cold it ceases to act. When the wool was sufficiently blue it was taken out in large balls, as big as a man's head, and at the same time squeezed and wrung over the vat, and immediately given to four or five women who stood round the vat, in order to open it and expose it to the air, between their hands, till the green colour which it had coming out of the vat changed to blue. This change was produced in three or four minutes. These thirty pounds being thus dyed, the vat was raked and then suffered to stand for two hours, keeping it always close covered. At the expiration of this time they put in another thirty pounds of wool, which was opened well with the hands. The vat was again covered, and in four or five hours this wool had taken as good a colour as the former ; it was then taken out of the vat in balls, in the same manner as the former. This operation being finished, the vat was still warm, but not sufficiently so to dye any more wool ; for when it has not a sufficient degree of heat the colour which it yields will be neither uniform nor solid ; hence it is necessary to reheat and replenish with indigo as before. This may be done as often as you think proper ; because this vat never spoils by age, provided that while it is kept idle you give it a little air.

TO REHEAT A URINE VAT

About four o'clock in the afternoon all the liquor was emptied into the copper, with the addition of a sufficient quantity of urine, to replace what had been evaporated and lost in the preceding work. This generally requires about eight or nine buckets of urine. The copper was then heated, the scum taken off as before; when ready to boil it was returned into the wooden vat. You add to it a pound of indigo, pounded and mixed with urine as above, a pound of alum, a pound of tartar, a pound of madder, and two quarts of urine. After the vat is stirred and close covered it is suffered to stand all night. It will be in a proper state the next day, and capable of dyeing sixty pounds of wool at twice, as above. In this manner the reheatings should be always done the day before you want to dye, and may be repeated *ad infinitum*.

It is necessary to observe that the more indigo you put into the vat at once the deeper the colour: thus instead of one pound, you may add four, five, or six, without increasing the quantity of alum, tartar, or madder; but if the vat contains more than three hogsheads, the quantity of the ingredients should be proportionably augmented. That which I have just mentioned contained only three hogsheads, and was consequently too small to dye at one time a sufficient quantity of wool to make a piece of cloth, viz. fifty-five or sixty pounds. To do this properly it should contain six hogsheads, which would be attended with a double advantage. First, all the wool might be dyed in two or three hours; whereas by twice dipping, it could not be finished in less than eight or ten. Secondly, at the expiration of the three hours the vat would be still very warm; so that after stirring and letting it settle for a couple of hours, the same wool may be dipped again.

By this means the colour is heightened almost as much more; because wool once dyed always take a much better colour than new or white wool, though suffered to remain in the vat even for twenty hours.

It is necessary to be very attentive in opening the dyed balls as soon as they are taken out of the vat, and exposing them to the air, in order to change them from green to blue, which should be done by many hands at the same time, that they may be equally affected by the air; else the blue colour will not be uniform.

Some manufacturers pretend that cloth the wool of which had been dyed in this urine vat cannot be perfectly scoured by fulling, even at twice; others affirm the contrary, and I believe they are right. Nevertheless if the first be right, one would suppose that the animal oil of the urine was become resinous, by drying on the wool, or that incorporating with the oil, by which the wool had been moistened for its other preparations, it would be more likely to resist the fullers' earth and soap, than simple oil by expression. To remedy this it is only necessary to wash the wool in running water after it has been dyed, expressed, and opened, ungreened and again cold. Be this as it may, a pastel vat in a large dye-house is preferable to these kind of indigo vats prepared with urine, because with a good woad vat and a dexterous woadman, you expedite more work than could be accomplished with any other blue vat. In mentioning the several indigo vats in this treatise, my design is not so much to introduce them into great manufactories as to assist those who work at small fabrics, to whom, I flatter myself, this treatise will be equally useful. I will even describe a cold vat for the dyers of small stuffs, mixed with thread or cotton, which succeeds very well, but which would be of no use for woollens.

CHAPTER IX

A Cold Indigo Vat without Urine

At Rouen and other towns of this kingdom they make use of a cold indigo vat, differing from that first-mentioned vat in the preceding chapter, which is more commodious, as it is much sooner ready and has no bad smell. It is prepared in the following manner:—

Three pounds of indigo, well pulverised, is put into a glazed earthen vessel and dissolved in three pints of soap-boiler's lixivium, which is a strong solution of fossil alkali with quick-lime. I have made use of a solution of potashes and succeeded very well. The solution of indigo is performed in about twenty-four hours, as may be easily discovered by its remaining suspended in the liquor, which is thereby thickened, and becomes like an extract. At the same time you put into another vessel three pounds of slaked lime, sifted, with six quarts of water. The whole should boil during a quarter of an hour, and when settled should be drained off clear. You afterwards dissolve in this lime-water three pounds of green copperas, suffering it to settle till the next day. You then put seventy-five gallons of water into a large deal cask, the only wood proper for the purpose, as any other, particularly oak, would blacken and tarnish the liquor. The two solutions, which had been prepared the night before, are then added, the vat stirred, and left to settle. I have seen it sometimes take the colour in two hours; but with this vat it was very different, not being ready

till very late the next day. It produces a great quantity of froth, and the liquor takes a fine green colour, but a little yellowish, something like the green of the common vat.

When the vat is almost exhausted it is replenished and quickened without fresh indigo by adding to it a small liquor, consisting of two pounds of green copperas dissolved in a sufficient quantity of lime-water. But when the colour of the indigo is quite exhausted it should be replenished with fresh indigo, dissolved in a lixivium, such as I have just described. It is natural to suppose that the quantity of your other ingredients must be augmented or diminished in proportion to the indigo. Some dyers use a mixture of vinegar and water impregnated with rusty iron. They suppose that the colour is thereby rendered more solid; but I am convinced by experience that there is no necessity for it, and that the colour is as permanent as any of the other blues prepared as I have directed above.

The first time I prepared this vat I proceeded according to a receipt sent me from Rouen. The soap-boiler's lixivium was simply denominated *strong water*. I suspected this to proceed either from malice or mistake. Nevertheless, as in matters of fact it is unjust to condemn without examination, I tried the common *aquafortis*, which produced the following effect:—

I took half a pound of indigo, well powdered, and steeped it in half a pint of common *aquafortis*, made with vitriol and saltpetre: this produced a fermentation. In this situation I left it for twenty-four hours, and having, as in the preceding operation, dissolved a pound of copperas in some lime-water, I poured these two mixtures into a cask containing about seventeen gallons of river water. I stirred it well, but there appeared nothing extraordinary the next day. I still continued to stir three times a day for two days together, and

then suffered it to rest for two days more, persuading myself that it was absolutely spoilt. At the expiration of these four days the liquor became of a red colour, but clearer than the pastel vats. I stirred it once more, and let it stand six days longer: it had then a little froth, but very pale; six days afterwards the surface of the liquor became brown, and underneath, a brown green. I stirred again, and fancied that the liquor underneath was still reddish, though the froth which it threw up was of a good colour; I therefore conceived hopes that it would do, and that I should be able to work it the next day.

At the expiration of sixteen hours I dipped some cotton, which took colour, but so very weak that I was obliged to let it remain in the liquor several hours, till the blue became sufficiently deep. It then withstood the summer air and sun tolerably well for twelve days; nevertheless I had the vat thrown out as useless, on account of its tedious operation. Doubtless it might have been recovered with lime or some other alkali that would have absorbed the acid of the *aquafortis*, but it was not worth the pains. Besides, the answer which I received from the person who sent me the receipt from Rouen contained an explanation with regard to the kind of *aquafortis* that should be used, from which I learnt that it should have been the soap-boiler's lixivium, which instead of being acid is one of the most caustic alkalies. In fact, by making use of this alkaline lixivium the operation was attended with immediate success, and never failed me since.

I tried several of these different vats in miniature, in cucurbits, put into a water or sand bath. These last are attended with no difficulty; it is only necessary to diminish the quantity of the liquor and of every ingredient, in proportion to your vat, and it is scarce possible it should not succeed.

Concerning that which I first described, and which is set hot, as it is attended with a little more difficulty, and that several persons may wish to try this operation themselves, being rather curious and requiring neither expense nor preparation, in miniature, I will give the description of a process which succeeded extremely well, and which I purposely supplied with much more indigo than is generally done in the common method.

I boiled two quarts of water with two drachms of madder and four ounces of pearl ashes. When it had boiled a quarter of an hour I poured it into a cucurbit containing about a gallon, which was previously heated with hot water, in which I had put a quarter of a handful of bran. The whole being well stirred with a deal spatula, I put my cucurbit into a very moderate sand heat, sufficient only to keep it warm, or nearly of the same degree of heat requisite in a common indigo vat.

I continued the sand heat all night and the next day without perceiving any alteration. I stirred it only twice during the day with the spatula. The day following it produced an efflorescence, formed a coppery scum on the surface, and the liquor became a brown green. I then filled it with a mixture composed of a quart of water, two ounces of pearl ashes, and a little bran. It was well mixed, and then left to settle. It became perfectly well coloured, and the next day I dyed several bits of woollen stuffs. These small vats are reheated and replenished with as much ease as a great one.

I think I have nothing more to add concerning the method of setting the different kind of vats for dyeing blue. Nevertheless I make no doubt but there are several other methods, used in different places, and that new ones may be invented without any great difficulty. I will only add that those which I have described may be depended upon, and that all of them were several times tried with equal success.

CHAPTER X

Of the Method of dyeing Blue

When the vat, of whatsoever kind it be, is once prepared and in a proper state, there is no difficulty in dyeing woollens or stuffs, as it is requisite only to soak them in clean warm water, to wring them, and then to immerse them in the vat, for a longer or shorter time, according as you would have the colour more or less deep. The stuff should be from time to time opened, that is to say, taken out and wrung over the vat and exposed to the air for a minute or two, till it becomes blue. For let your vat be what it will, the stuff will be green when taken out, and will become blue when exposed to the air. In this manner it is very proper to let the colour change before you immerse your stuffs a second time, as you are thereby better enabled to judge whether they will require only one or several dips.

'Tis a custom with dyers to enumerate thirteen shades of blue, from the darkest to the lightest. Though their denominations are rather arbitrary, and that it is impossible to fix their just gradation, it is however necessary to distinguish them by such names as are found in the instruction for dyers published in 1669 by order of M. Colbert. They are as follows, beginning with the lightest:—

White blue, pearl blue, pale blue, faint blue, delicate blue, sky blue, queen's blue, turkey blue, king's blue, garter blue, Persian blue, aldego blue, and infernal blue.

These distinctions are not equally received by all dyers in every province; but the greater part are acknowledged by them as necessary to form some idea of the same colour, differing only by being more or less dark.

There is no difficulty in dyeing dark blues, it being required only to repeat the dipping at several times. But it is different with regard to light blues, it being often dangerous, when the vat is in a proper state, to let the woollens remain long enough to take the shade you want. It even frequently happens that when there is a certain quantity of wool to be dyed, and that it is impossible to put it into the vat at the same instant, the first batch will imbibe the deepest shade. To avoid this inconvenience some dyers, in order to procure the lightest blue, which they call bleached or white blue, dilute their indigo vat with a quantity of warm water. But this is a bad method, because the colour obtained from this mixture is nothing like so permanent as the colour of the original vat; for the alterant ingredients of the indigo vat, serving as much to open the pores of the subject dipped as to develop the colouring matter, they are necessary to the permanency of the colour. The best method of producing these light blues is to dip them in the vats, whether indigo or pastel, when the colour is exhausted, and when they begin to grow cold. The pastel vat is the best for this purpose, because it does not dye quite so quick as the indigo; but this observation I have made before.

It is very certain that blues dyed in the exhausted vats will be less bright; but they may be very sensibly enlivened by passing the stuffs or wool through boiling water. This practice is even necessary for the improvement of all blue shades; for besides rendering the colour more lively and fixed, it also cleanses the stuffs from those loose impurities which soil the hands and linen, as is almost constantly the case: in order to save time the dyers are too frequently negligent in this

particular. When the work is taken out of the hot water it should be rinsed in a running stream.

If a dark blue, it were still more advisable to full it well in soap and water, and afterwards to rinse it at the river. The soap will not in any respect injure the blue; it will, on the contrary, make it more bright and lively.

Stuffs which are dyed blue in order to be dyed black, should be cleansed with equal care, as shall be specified in my article upon black; but for those to be dyed green it is not quite so necessary; the reason of which will appear when I come to speak of that colour.

There remains, I think, no other difficulty with respect to the preparation of blue and to the method of dyeing this colour. Some dyers dishonestly, in order to save pastel and indigo, make use of logwood; but this, though frequently more lively than a solid and legitimate blue, should be expressly prohibited. I shall be more explicit in this particular when treating of colours not *in grain*.

There remains only to explain the invisible mechanism of the blue dye. This colour, considered only with respect to its utility in dyeing all sorts of stuffs, has been hitherto obtained from the vegetable kingdom only; nor is there any probability that the painters' blues will ever be employed in the art of dyeing, viz. Prussian blue, which is a species of animal and mineral substance [*in* 1748 M. Maquier, *of the Royal Academy of Sciences, discovered a method of dyeing silk and cloth with a preparation of Prussian blue, superior to all the blues that had been hitherto dyed*]; azure, which is a vitrified mineral; ultramarine, which is obtained from a hard stone prepared, or the blue earths, etc. These various substances cannot, without wholly or in some degree losing their colour, be reduced into atoms sufficiently minute to be suspended in the saline liquid, which should penetrate the fibres of what-

ever substance the stuff is made,whether animal or vegetable. Under the word stuff, I comprehend in this place as well linen and cotton as silk and woollens.

Hitherto we know of only two plants capable of dyeing blue, viz. *isatis* or *glastum*, called pastel in Languedoc, and woad in Normandy. It is prepared by fermenting, almost to putrefaction the entire plant, except the root, consequently it consists in a development of their principles in a new combination and arrangement of these same principles; hence results an assemblage of particles, infinitely subtle, which being applied to any subject, reflect rays of light very different from those which they would have reflected, were the same particles still joined to those which had been separated by fermentation.

Anil, the other plant, cultivated in the East and West Indies, is prepared and sent to England under the name of indigo. In the preparation of this last plant the Indians and Americans, more industrious than we are, have discovered the art of separating the colouring particles from those which are of no use; and the French and Spanish colonies, after their example, make it a considerable article of commerce.

The indigo imported from America, and which transfers its colouring particles, of so much consequence in the art of dyeing, to the manufactured stuffs or wool, is infused in the several ways described above. These may be reduced to three: The infusion of the cold indigo vat, used for thread or cotton; the hot vats used for all kinds of stuff. To the cold vat is added, besides the indigo, pearl ashes, copperas, or green vitriol, lime, madder, and bran. The hot vats are prepared with water or urine. If with water, you add some pearl ash, and a little madder; if with urine, a little alum and tartar. Either of these vats, designed chiefly for woollens, require a moderate degree of heat, sufficient, however, to give the wool a permanent

colour; that is to say, as I have already observed, a colour capable of resisting the destructive effects of the air and sun, and of the trials enjoined, a detail of which may be seen in the new *Instructions* of 1733.

I have myself prepared, as I observed, these three vats in miniature, in cylindrical glass vessels exposed to the light, in order to observe the effect before the infusion acquired colour, viz. before it became green under the scum or blue on the surface, which is a sign of interior fermentation. This green colour is, as I have already said, absolutely essential to the liquor, and without which the colour of the stuff would entirely fade by the smallest trials.

I will now describe the small cold indigo vat, because in this the variations are more easily discernible, and because there is no very essential difference between it and the two others. It is, however, necessary, before I proceed, to intimate that by the word *part* in this experimental memoir I mean a measure weighing four drachms, or half an ounce of any substance whether liquid or solid, and that this is the quantity meant as often as I make use of the term *parts* in the account of these experiments.

I have put 300 parts water in a vessel containing five hundred and twelve of these parts, or two gallons, in which I dissolved six parts of green copperas, which gave the liquor a yellow tinge. I then dissolved six parts potash in thirty-six parts water separately; when the solution was complete I digested over a very slow fire for three hours, six parts, or three ounces of indigo of St. Domingo well bruised. It swelled very much, and rising from the bottom of this alkaline liquor formed a kind of syrup, thick and blue, by which it appeared that the indigo was only divided, not dissolved; for had the solution been perfect, this thick liquor would have been green instead of blue; because all liquor, if coloured blue by

any kind of vegetable, becomes green when mixed with an alkali, whether fixed or volatile. Hence we begin to discover why indigo does not dye stuff a permanent blue when the liquor is not green; for in that case the solution is not complete, and the alkali cannot act on the first elementary particles, as for instance it acts on the tincture of violets, which being a perfect solution of the colouring particles of these flowers, becomes instantly green.

I poured this thick blue liquor into a solution of vitriol, and having stirred it well, added six parts of lime, slaked in the air. This experiment was made in cold weather; the thermometer was two degrees below the freezing point; hence this vat was near four days in coming to its colour; but the fermentation, which necessarily takes place in all vitriolic liquors mixed with an alkaline salt, such as potash or an alkaline earth, went on so slowly that there was but very little appearance of froth or air-bubbles on the surface of the liquor. In a warm season, and by using lime, fresh calcined, these vats are sometimes in a proper state for dyeing in the space of four hours.

As often as this mixture was stirred with the spatula I always remarked that what first fell to the bottom of the vessel was the iron of vitriol, or the copperas which had been precipitated by the alkaline salt uniting with the acid. Hence in the operation of the cold indigo vat a vitriolated tartar is formed, in the manner of Techenius; whereas in the common method of preparing this neutral salt an acid spirit of vitriol is poured on a true alkaline salt, as salt of tartar or potash. This circumstance insensibly leads to the theory of dyeing the good dye; I must entreat the reader to bear this in mind, as I mean to avail myself of it in the sequel of this memoir.

After the iron is precipitated you perceive the earth of the lime fall to the bottom: this is easily perceived by its white-

ness, which does not begin to change to a colour more difficult to distinguish till the colouring particles of the indigo are in some degree developed. At last the dregs of the indigo deposits on the top of this white earth, which gradually rarefies in such a manner that the substance, which on the first day occupies no more than an inch on the top of the precipitated lime, rises insensibly within half an inch of the surface of the liquor, which on the third day becomes so opaque that nothing more can be distinguished.

This rarefaction of the indigo, slow in cold weather and quick in summer, and which in winter may be accelerated by giving it fifteen or eighteen degrees of heat, is a proof that a real fermentation takes place in this mixture, by which the atoms of the indigo are opened and divided into particles of an extreme tenuity. Their surfaces being thus multiplied almost *ad infinitum*, they are thus more equally distributed in the liquor, which is thereby rendered more capable of depositing uniformly the colouring atoms on the subject immersed in order to be dyed.

If this fermentation be accelerated by heat you perceive on the surface of the liquor a great quantity of blue froth, which has a copperous tinge, because it reflects the colours of the rainbow, in which the red and the yellow predominate; this phenomenon is not, however, peculiar to the indigo, as all mixtures in the act of fermentation, especially those which contain oily and saline particles, have the same appearance. Urine, sweat, and many other bodies when in a fermenting state, produce these rainbow colours on their surface.

The froth of the indigo vat appears blue because it is exposed to the exterior and contiguous air, but if you take a little of the liquor from under the froth with a ladle it will appear more or less green in proportion as it is more or less saturated with the colouring particles. The reason of this difference will be shown in the sequel of this memoir, or at least a prob-

able application of this blue change, which, as I have before observed, is absolutely necessary towards the success of the operation described.

When the vat is in this state, as I have said before, it is capable of dyeing cotton, thread, or linen, etc., and the colour taken by these bodies is durable and *good*; that is to say, will keep their colour though they should remain for a considerable time in a boiling solution of soap-suds. This trial is preferable to all others, because cottons and linens when dirty are whitened by soap.

Though the indigo vat when in this state will dye well without the addition of any other substance, the dyers, who are accustomed to the cold vat, add, as in warm vats, a decoction of madder and bran in common water and strained through a sieve. This they call *bever*. The madder is added, as they say, to fix by its tenacity the colour of the indigo. And the bran to sweeten the water, which, as they imagine, almost constantly contains some particles of an acid salt, and which in their opinion it is necessary to counteract, at least such are the sentiments of those whom I have consulted.

This is the remains of the ancient prejudice against indigo which subsisted in M. Colbert's time; and this minister, whose great employments prevented him from being a witness to the experiments upon which he pronounced judgment, prohibited the use of indigo alone. Nevertheless, since the Council, convinced by the experiments of the late M. Dufay, has acknowledged the stability of the blue dye of this ingredient to be equal to their wish, the new *Regulation* of 1737 has left the dyers at liberty to use it either alone or mixed with the pastel. Hence, though they still continue to use madder, it is only because this root furnishes rather a deep red, which, mixing with the indigo, gives a sort of violet tinge and has a better effect to the eye.

With regard to the bran, when used it is not so much to neutralise the supposed acid in the water as to diffuse a certain quantity of mucilage or viscous substance; for the small quantity of farina which remains in the liquor of the vat diminishes in some degree its too great fluidity, and consequently prevents the colouring particles therein suspended from precipitating with so much velocity as they would otherwise do in a liquor which had not acquired a certain degree of thickness.

Notwithstanding this gluten diffused in the liquor, both from the bran and madder, which also furnishes a glutinous substance, the colouring particles will fall to the bottom of the vessel if suffered to remain for some days without stirring. In this case the subject dipped in the top of the liquor obtains but a faint tinge; and therefore if you would have it take a proper colour you must again stir the mixture, and then let it rest for an hour or two till the iron of the copperas and the gross particles of the lime are, by their own weight, again precipitated; left in mixing with the real colouring particles, they should injure their effect by depositing on the subject to be dyed certain loose particles, which in drying would render it powdery, and of which each atom would occupy a space where the real colouring particle could neither be introduced nor deposited in immediate contact with the subject.

Pursuing the common method, I boiled one part of grape-madder and one part of bran in a hundred and seventy-four parts of water. This proportion of water is not necessary; you may put more or less; but I filled my vessel, which contained five hundred and twelve parts, as I have said above. I strained this *bever* through a linen, by expression, and then put it, still warm, and of a blood-red, into the indigo vat, observing the necessary precaution not to break the crystal vessel in which it was contained. I stirred the whole, and at

the expiration of two hours the liquor became green, consequently ready for use; and in effect it dyed cotton of a solid and more lively blue than before the addition of the madder.

Let us now inquire into the particular cause of the solidity of this colour, which will probably be the general cause of the tenacity of all others, for it appears from the above-mentioned trials that this tenacity depends on the choice of the salts, added to the decoctions of the colouring ingredients, when the same ingredients do not of themselves contain something of the same nature. If with the consequences which I deduce from the choice of these salts, of their nature and of their properties, we admit what cannot justly be objected to, viz. the greater or less degree of tenuity, or homogeneousness of the colouring particles of the ingredients used in the art of dyeing, the whole theory of this art will be soon understood, without the necessity of supposing uncertain or disputable causes.

It may be easily conceived that the salts which are added to the indigo vat are as necessary for opening the pores of the subject to be dyed as for developing the colouring atoms of this drug. In other preparations for dyeing, which shall be mentioned in the sequel of this treatise, the stuffs are boiled in a solution of salts, called by the dyers *preparation*. In this they generally use tartar and alum. At the expiration of some hours the stuff is taken out, lightly squeezed, and kept moist in a cool place during some days, that the saline liquor may continue to act, and prepare it to receive the colour of the ingredients, in a decoction of which it is afterwards boiled. Without this preparation we are taught by experience that the colours would not be solid, at least in most cases. It must be confessed, however, that there are some ingredients which, though the stuffs are not previously prepared, give a permanent colour; but that is when the ingredients themselves contain the preparatory salts. It is there-

fore necessary to enlarge and cleanse the natural pores of the fibres of the wool by the assistance of these salts, which are in some degree corrosive, and perhaps also to open fresh pores, in order to lodge the colouring atoms. These atoms are forced into them by the ebullition of the liquor with repeated strokes. The pores, already enlarged by these salts, are still more dilated by the heat of the boiling water, and afterwards contracted by the external air, when the stuff is taken out of the copper, when exposed to the air, or when plunged into cold water.

If besides this elasticity of the sides of the pores we suppose that their insides are lined with a coat of the saline liquor, it is easy to conceive that this will be another artificial means of retaining the colouring atoms; which having entered into the pores whilst this saline lining was in a state of solution, consequently liquid, and this lining being afterwards congealed by the external cold, the atoms are retained both by the above-mentioned elasticity and by the lining, which, becoming hard by crystallisation, forms a kind of mastic. If, moreover, the coloured atom be of such tenuity that the small eminence which remains apparent at the orifice of the pores, and without which the subject would not have the appearance of being dyed, be not so far elevated as to expose it to shocks sufficiently powerful to overcome the resistance of the sides, and of the gluten by which it is retained, we may conclude that the colour resulting from these atoms thus properly confined, will be extremely solid, and may be termed *good dye*, provided the saline gluten cannot be destroyed either by the heat of the sun or moisture of the air.

We know of only two salts in chemistry which being once crystallised will not dissolve in cold water; for there is scarce any other salt but will be reduced into meal or white dust by being for many days exposed to the sun. These salts are tartar, either as it comes from the wine casks or purified, and

vitriolated tartar. All other salts want one of these two properties. Vitriolated tartar may be made by a mixture of any salt, the acid basis of which is vitriolic, as copperas and alum, and a salt already alkalised, or which when deprived of its acid may become alkali, and which may be easily accomplished provided it be weaker than the acid of vitriol, such as the acid of all essential salts procured from vegetables.

In the operation of the blue vat which I worked in miniature, in order to try its effects, I mixed copperas and potash, which is an alkaline salt ready prepared. As soon as their solutions became united the iron of the copperas was immediately precipitated into a blackish powder by the alkali. The vitriolic acid of the copperas, having no longer a metallic basis, unites with the alkali and forms a neutral salt called vitriolated tartar, the same as if it had been made with the oil of vitriol and salt of tartar. The theory of the above process is easily understood ; but it is probably not so with regard to the liquor required for other colours, as red and yellow. It will not be allowed perhaps that it is possible to form vitriolated tartar with a mixture of alum and crude tartar boiled together. The theory is, however, the same, and I cannot see how it is possible to conceive it otherwise. Alum is a salt in which vitriolic acid is united to an earth ; by adding to it an alkaline salt this earth will be instantly precipitated and the vitriolated tartar immediately formed. Now instead of this alkaline salt you boil alum with crude tartar, which is the essential salt of wine, viz. a salt composed of the acid of wine, which is much more volatile than vitriolic acid, and an oil, both concentrated in a small portion of earth. This salt, as all chemists know, becomes an alkali when deprived of the acid. Hence by boiling alum and crude tartar together, besides the impression which the fibres of the stuff to be dyed receive from the first of these salts, in some degree corrosive, the tartar

is thereby purified; and from being dirty and impure becomes clean and transparent by means of the earth, which is separated from the alum, and which has on the tartar nearly the same effect as the earth of merviels used at Montpelier in the manufacture of cream of tartar. It may also happen that the vitriolic acid of the alum, expelling a part of the vegetable acid from the tartar, forms a vitriolated tartar as hard and transparent as the crystals of tartar. Let us admit on either supposition, the result will always be a saline coating in the open pores of the fibres of the wool, which as soon as the stuff is taken out of the dye and exposed to the fresh air crystallises; but it neither calcines by the heat nor dissolves in cold water, which is all I mean to demonstrate by this unavoidable digression.

This theory applies also to the indigo vat, where urine is added instead of water, and alum and crude tartar in the place of vitriol and potashes. With urine it cannot give a permanent colour but when it is very hot, and it is even necessary to leave the wool immersed in it for an hour or two if you would have it equally dyed. As soon as this vat is again cold it gives no more colour. The cause of these facts would be difficult to discover in an opaque metal vat, but in a glass vessel may be easily seen. I suffered this little experimental vat to grow cold, and all the green colour therein suspended fell by degrees to the bottom of the vessel; because then the tartar became crystallised, and uniting in heavier masses, fell to the bottom, and drew along with it the colouring particles. When I gave this liquor its former degree of heat, stirred it, and afterwards let it stand a while, I put into it a little bit of cloth, which at the expiration of an hour was taken out as permanently dyed as at the first time. Hence when this vat is used, and that it is once in a proper state, it requires no more than to keep the tartar dissolved, which must be done by a pretty strong heat. The alkali of the urine makes it green;

the alum prepares the fibres of the wool; and the crystals of tartar confirm the colour by cementing the colouring atoms deposited in the pores.

There remains a difficulty with regard to the indigo vat, in which neither vitriol, alum, nor tartar are introduced; in which nothing more is put than pearl ash, in equal quantity with the indigo, and which is heated pretty strongly in order to dye the woollen stuffs. Before I can account for the solidity of this colour, which is equal to any of those blue vats with the salts I have just mentioned, it will be necessary to examine the pearl ash. It is well known that pearl ash is made from the lees of wine dried, and then calcined. It is therefore an alkali of the same nature of salt of tartar, but less pure, as it proceeds from the heaviest parts of the lees of wine, consequently the most earthy. Besides the alkali of the pearl ash is never so homogeneous as the alkaline salt of tartar, well calcined, and there is scarce any unpurified pearl ash, such as is generally sold, from which you cannot obtain a considerable quantity of vitriolated tartar. It is even probable, by an experiment which I have related elsewhere, that the whole may at last be converted into this neutral salt; the same may be said with regard to potash, and to all the alkaline salts which do not contain the basis of marine salt. The want of homogeneity is the reason why pearl ash is never entirely deliquescent in the air, and besides, as we are taught by experience that there is in pearl ash a vitriolated tartar already formed, it is clear that this indigo vat, which does not dye wool well till after the liquor has been heated so hot that you cannot bear your hand in it for any time without burning, will dissolve the small portion of vitriolated tartar; consequently this salt introduces itself into the pores of the wool in order to cleanse and coat them, and will coagulate as soon as the wool is taken out of the liquor and exposed to the air.

I must also explain why the indigo vat is green under the first surface of the liquor; why it is necessary that the liquor should be green in order to make the blue colour durable; and why stuffs taken out of the vat green should become blue immediately upon being exposed to the air. These circumstances being necessarily common to all indigo vats, whether hot or cold, the same explication will serve for all.

1st. The froth or scum which rises on the surface of the indigo vat when in a proper state for working is blue, and underneath the froth the vat is green. These two circumstances prove that the indigo is perfectly dissolved, and that the alkaline salt is united to the colouring atoms of this ingredient, else instead of being green it would remain blue.

2nd. The same circumstances prove that the indigo itself contains a volatile alkali, which being developed by the fixed alkali of the potash or by the terreous alkali of the lime, evaporates in a very little time after this froth has been exposed to the air. We may be convinced of the existence of this volatile spirit by attending to the smell of the vat during the time of fermentation, for when heated or stirred you will perceive a smell like that of tainted meat in the act of roasting, with something pungent.

3rd. The preparation of the *anil*, in order to separate the dregs, is a continued fermentation, even to putrefaction. Now there is in all putrefied plants a urinous volatile alkali; whether this volatile alkali be produced by an intimate union of the salts with a vegetable oil, or whether it be owing to the prodigious multitude of insects which, being attracted by the smell, infest the fermenting plant in all parts: they live on them, multiply and die, consequently leave an infinite number of dead bodies. Hence there is an animal substance added to the vegetable, the salt of which animal substance is always a volatile alkali. The same urinous quality also exists in the pastel, which is

in the same manner prepared by fermentation and putrefaction, as you will presently perceive in the abridged account of its preparation.

4thly and lastly. If indigo or pastel be distilled in a retort, whether alone or, which is still better, with the addition of a fixed alkali, either saline or terreous, you will thereby procure a liquor which in all chemical experiments produces the effect of the volatile spirit of urine.

But it will probably be asked why this volatile alkali existing in the indigo does not make it green, being equally distributed in every part? Why indigo, dissolved in boiling water, turns it blue and not green? I answer that this volatile spirit is so concentrated that it requires an extraneous body more powerful than that of boiling water to disengage it from the particles by which it is enveloped; that the solution of indigo is never perfectly accomplished by water alone, be it ever so hot; that it is only disused, and not dissolved; that in fact the decoction of indigo will blue the stuffs, but that the blue colour will be so very unequally applied that other boiling water will immediately wash it out. Let me also beg leave to answer by an example deduced from another subject. The sal-ammoniac from which the chemists obtain their most penetrating volatile spirit, has not when dissolved and boiled in water this strong urinous smell; it is therefore necessary to add either lime of a fixed alkaline salt in order to disengage the volatile spirit. Indigo, in the same manner, requires fixed alkalies, either saline or terreous, to be completely decomposed to render its volatile spirit perceptible and to reduce its colouring atoms to their elementary tenuity.

I now proceed to the second condition, viz. that the liquor of the indigo vat should necessarily be green in order to produce a permanent colour. For, as I have already said, the indigo would not be quite dissolved unless acted upon by an

alkali, and its solution not being so perfect as it ought, would dye neither equally nor solidly. As soon therefore as the alkaline salt acts upon it, it becomes green ; because all alkalies when mixed with the juice or blue dye of a plant, or of any flower whatsoever, when equally distributed through all its colouring particles, become instantly green. But if by evaporation these same particles, either coloured or colouring, be collected into hard compact lumps, the alkali cannot change their colour until it has penetrated, divided, and reduced them to their original tenuity. This is the case with respect to indigo, which is, properly speaking, the inspissated juice of the *anil*.

With regard to the third and last condition, viz. that the stuff when taken out of the liquor should be green, and being exposed to the air should become blue, without which circumstance it would not be permanent, it may be accounted for in the following manner:—It is taken out green because the vat is green ; if it were not green the alkaline salt which had been put into the vat would not be equally distributed, or rather the indigo would not be entirely dissolved. If the alkali had not been equally distributed the liquor of the vat would not be equally saline. The bottom would have all the salt and the top would be insipid ; in which case the stuff immersed would neither be prepared to receive or retain the colour. But when at the expiration of a quarter of an hour it is taken out green, it is then evident that the liquor is equally saline and equally impregnated with the colouring atoms. It also proves that the alkaline salt was capable of penetrating into the pores of the fibres of the stuff and of enlarging them, or, as I have already remarked, of forming new ones. It is therefore obvious that an alkaline salt will produce this effect on woollen stuffs if it be remembered that an alkaline lixivium, when very acrid, will burn and consume a lock of wool or a

bit of feather almost instantly. Of this the operation of dyeing called *fonte de bourre,* or a solution of cows' hair, is another proof. The hair employed for this purpose is boiled in a solution of potash with urine, in which solution it is so perfectly dissolved that not the least fibre remains. Therefore if a lixivium extremely acrid will destroy the wool, a lixivium containing no more alkaline salt than what is sufficient merely to make it act on the wool without destroying it, will prepare its pores to receive and preserve the colouring atoms of this ingredient, which is the object of this dissertation.

The stuff is opened after being taken out of the vat and wrung or squeezed; it then becomes blue. What is done by opening it? It is cooled. If it be the volatile alkali that is extricated from the indigo which has given it this green colour, it evaporates, and the blue appears. If a fixed alkali occasions this green, besides that the greatest part of it is discharged by the strong expression of the stuff, what remains can no longer act on the colouring particles; because the minute atom of the vitriolated tartar, containing a colouring atom still more minute, crystallises as soon as exposed to the cold air; and embracing this colouring atom by means of the elasticity of the sides of the pores entirely presses out all that could possibly remain of the alkali, which does not crystallise like a mineral salt.

This blue is enlivened, that is to say, rendered more bright and beautiful, by immersing the stuff which had been just dyed in hot water, because then the colouring atoms which adhered to the fibres of the wool only superficially are carried off. Soap is used to try the solidity of the blue dye, which it resists because the soap (of which only a small quantity is dissolved in a large proportion of water, and the pattern remaining in it for five minutes only, the time required) being an alkali mitigated by an oil cannot possibly act upon a neutral

salt. If it discharges any part of the colour, the particles discharged must have adhered but superficially. Besides, the small saline crystals wedged into the pores cannot be dissolved in such a manner as to quit them with the colouring atom.

In this dissertation I have exhibited an essay of my method of treating the art of dyeing, different from what has been hitherto practised. Philosophers, to whom it is submitted, would not be satisfied with a simple narrative of experiments, were I not at the same time to present them with a theory of their success. I shall observe the same method with regard to the reds and yellows, which are also simple colours ; because it is absolutely necessary to understand them before we proceed to compound colours, as the last are colours generally applied one upon the other, and seldom mixed together in the same vat. Hence by being informed of what procures the tenacity of a simple colour we are enabled to judge more easily whether it be possible for the atoms of the second colour to possess the vacant spaces between those of the first. On this principle I have formed my arrangement of the different colours to be applied to the same stuff ; because I find it difficult to conceive even a possibility that the colouring atoms, being deposited one upon another, should thereby form a kind of pyramid, each preserving its colour, so that from a mixture of the whole there should result a compound colour, appearing nevertheless uniform or rather homogeneous. To believe this we must necessarily suppose what it would be very difficult to demonstrate, that these atoms are transparent. Besides that a yellow atom should be immediately applied on a blue atom, already enclosed within the pore of the fibres of the stuff in order to be permanently fixed, it is necessary that their parts in contact should be extremely polished. That a red atom should afterwards be deposited on a yellow, we

must suppose new planes, no less accurate and equally polished than the first. Imagination can hardly give credit to all these suppositions; but it appears to me much more probable that the first colour occupied only the pores that were left open by the first preparation of the fibres of the stuff; that close to the pores already filled there remain spaces not occupied where new pores may be opened for the reception of the new atoms of a second colour by the assistance of a second preparation.

What I have said in order to explain the method of conducting an indigo vat, will also serve to show the action of the pastel vat on woollens and stuffs: we need only suppose that the pastel vat naturally possesses salts nearly of the same nature with those which are added to the indigo vat.

By the description which I have given of each of these vats it appears that the pastel vat is infinitely more difficult to conduct than the other. In my opinion it may be rationally supposed that all these difficulties might be removed by preparing the *isatis* in France in the same manner as the *anil* is prepared in the West Indies; we will therefore compare these two preparations. I shall transcribe the following quotation from the memoirs of Mr. Adstruc, on the *Natural History of Languedoc* (Paris, Cavalier, 1737, in 4to, pp. 330, 331):—

"The colours obtained from the pastel, according to the dyers, are faint and weak, while those obtained from the indigo are bright and lively. It must indeed be confessed that this opinion is conformable to reason. Indigo is a fine subtle powder, consequently capable of penetrating the stuffs and thereby giving them a bright colour. Pastel, on the contrary, is a thick paste, clogged with a quantity of earthy particles, by which the action and motion of the subtle particles are impeded and prevented from being efficacious.

"The method of remedying this evil is to prepare the pastel in the same manner as the indigo, by which means you would give the colours obtained from the pastel a brightness and vivacity equal to those obtained from the indigo, without in the least diminishing the excellence and solidity which particularly recommends those colours in which the pastel is concerned.

"I have already," continues Mr. Adstruc, "made experiments of what I now propose, in miniature, and these experiments have been successful not only in the preparation of the powder of the pastel, but also in the use of this powder for dyeing. It depends upon those intrusted with the public weal to cause experiments of the same nature to be made upon a larger scale; if attended with the success to be expected it will be incumbent on them to encourage the cultivators of the pastel to adopt this new method of preparation, and to regulate whatever encouragement they may think proper to give at the commencement, in such a manner as to support the expenses incurred by this new practice, till they are themselves determined by the advantages resulting from it."

I was ignorant that Mr. Adstruc was of my opinion when I first proposed to try the American method in Languedoc; but having since read his memoir, I was delighted to find that my ideas coincided with the opinion of this great man: as it succeeded in miniature, it is probable that a larger undertaking would be attended with equal success.

With regard to the manufacture of the pastel I shall quote Mr. Adstruc, whose account will not, I think, be unacceptable in this work:—

"The peasants of Albigeoise are accustomed to distinguish two different seeds of pastel, the one violet and the other yellow. They prefer the violet because the leaves are smooth

and even, whereas the leaves of the other are hairy, and therefore less valuable, as the dust and sand adheres to them. This pastel is called *pastelbourg*, or *bourdaigne*.

"The pastel shoots out five or six leaves, which while green are upright. They are about a foot long and six inches broad. They begin to ripen near midsummer; when ripe they bend downwards and turn yellow. They are then cut, etc. The ground should be afterwards hoed, which should be repeated after every cutting.

"It should be cut a second time in July, if the weather has been rainy. Wet or dry weather either accelerate or retard it for eight days. At the latter end of August it should be reaped again. They make a fourth cutting the latter end of September, and about a week after All Saints they cut for the last time. This interval being longer, it has more strength than the others: at this crop they cut the neck of the plant, viz. the top of the root, whence the leaves proceed. The pastel produced from this cutting is bad, and therefore prohibited by the *Regulations*.

"The pastel is never reaped in wet or foggy weather. It is necessary that the weather be very fine and the leaves dry.

"At each crop the leaves are immediately conveyed to the mill and ground to a fine paste. This should be done immediately, because the leaves when heaped together soon ferment and rot, with an insupportable stench. These mills are something like rape mills. They consist of a mill-stone fixed on its edge, which goes round a perpendicular pivot, in a pretty deep circular grove, in which the pastel to be ground is deposited. Mr. Adstruc has given an engraving of this machine.

"When the leaves are by this means reduced to a fine paste, it is piled up in the galleries of the mill, or in the open air. When the paste has been pressed with the feet and hands

it should be beaten, and smoothed on the surface with a shovel. This is called pastel in piles.

"The outside forms a crust which becomes blackish. When it begins to crack it should be carefully smoothed again, otherwise the air gets in and produces little worms in the crevices, by which the pastel is spoiled.

"The heaps are opened at the expiration of fifteen days, broken with the hands, and mixed together, crust and all; but the crust is sometimes so hard that it is necessary to break it with a club.

"The paste is afterwards made into little round balls. In forming these balls they should be well squeezed, and afterwards given to another person, by whom they are moulded into a wooden mould, again squeezed and made oval; finally they are given to a third person, who finishes them in a smaller mould.

"These balls are laid upon hurdles and exposed to the sun, if the weather be fine; but if not, they are deposited over the mill. The pastel exposed for some hours to the sun grows black at the outside, while that which is dyed in the shade is generally yellow, particularly if the weather be rainy. The first is preferred by the merchants; it is nevertheless asserted that there is not much difference. It even frequently happens that the pastel is all yellow, because the peasants by whom it is made generally work at it in rainy weather, when they can do nothing else.

"The balls in summer are generally dried in about fifteen or twenty days, but in autumn the pastel of the latter crop is a long while drying. It dries much faster with a south-east wind.

"The best balls are distinguished from the others by being, when broken, of a violet colour at the inside; the bad ones, on the contrary, have a bad smell and an earthy colour, the

consequence of having been cut in rainy weather when the leaves were covered with earth. You may also judge of their goodness by their weight, as the substance not being well squeezed evaporates and becomes rotten, consequently lighter.

"The powder of pastel is made of these balls. The operation is performed in the following manner, and requires at least a hundred thousand balls:—You should have a detached barn and a magazine, greater or less, according to the quantity of the pastel. This magazine should be on a floor paved with bricks, and lined with the same four or five feet high. It were advisable to have the outside walls stone, of the same height.

"It is however frequently thought sufficient to have them plastered at the inside with earth; but this plaster comes off and mixes with the pastel, which is thereby impaired and spoilt. The balls are brought into this magazine, where they are broken into gross powder with wooden mallets. The powder is then heaped near the middle of the magazine, about four feet high, leaving a space for the conveniency of going round it: it is wet with water—pond water is the best, provided it be clear. [*I see no reason why pond water, however clear, should be preferred to clear river water, which would be much more safe, being exempt from the inconveniences necessarily attending putrid water, such as a constant bad smell, being muddy, and containing a quantity of useless earth, which must render the dyeing with this drug very unequal.*] The pastel thus moistened ferments, grows hot, fumes, and emits a very offensive smell.

"The pastel is stirred every day for twelve days, shovelling it from one side of the magazine to the other, and wetting it every day during that time, after which it is wet no more: it is then sufficient to stir it only every two days, and afterwards every three, four, and then five days. Finally it is

heaped in the middle of the magazine, and from time to time visited, in order to give it air in case it should heat. This is the powder of pastel as prepared for the dyers."

Mr. Adstruc, in order to prove that Upper Languedoc was enriched by the pastel trade, quotes the following passage from a book entitled *Le Marchand*:—" It was formerly the custom to transport every year into Toulouse and Bourdeaux, by the river Garonne, a hundred thousand bales of pastel, which in that country sold for at least fifteen livres a bale. This, amounting to one million five hundred thousand livres, produced abundance of money and riches in that country." So says Castel, author of the book above cited, in the year 1633 (*Memoires de le Histoire du Languedoc*, p. 49).

The comparison of the two methods of preparing the pastel and indigo will be sufficient to any intelligent person commissioned to try the possibility of producing an extract from the *isatis* of Languedoc resembling that of the *anil*. We must not expect this from either the dyer or manufacturer. They will at once condemn the project, because new; and I question much whether they would be capable of properly conducting a fermentation. I could wish to have this experiment tried on a large scale, so as to have at least fifty pounds of this extract, that several vats may be set in case the first should fail. The person chosen for this experiment should be very accurate in his description of every circumstance relative to the operation. He would perhaps fail in the leaves that were first reaped, because in June they have not sufficient heat, but in the month of August he would in all probability succeed.

By letters which I received from Mr. Roman the younger, engineer-general at Dominica, I learn that during the hottest season in the island of Martinico, the thermometer rises from thirty to thirty-six degrees of Mr. Réaumur's scale. That in

Languedoc it rose from twenty-seven to thirty-two and thirty-three, the heat of the human body ; a heat sufficient to produce the fermentation of the pastel leaves, which should be steeped and macerated in the same manner as the *anil,* in a large vat built of stone. The fermentation will perhaps require no more than thirty or forty hours. It may be accelerated by throwing three or four cauldrons of warm water into the vat.

The person intrusted with this experiment should procure leaves as little withered as possible, which perhaps ought to be slightly bruised. For the first experiments he should have vats constructed of masonry, a third of the size of those the dimensions of which were given by P. Labat. But the whole of the process being perfectly described in his *Memoirs,* there remains only to follow his instructions. If this experiment should succeed it is probable that there are many other plants of the same nature of the *isatis* which would produce the same extract. The deep green of many plants is probably composed of yellow and a large proportion of blue particles. If the yellow particles be destroyed by fermentation the blue will still remain. This idea is not perhaps absolutely chimerical, nor would it be difficult to prove that some utility may be drawn from it.

CHAPTER XI

Of Red

Red, as I have already mentioned, is acknowledged by the dyers as one of the five primitive colours. There are in the great dye four different sorts of reds, which are the basis of all the rest. There are, first, scarlet in grain, formerly called French scarlet, now Venetian scarlet. Secondly, the scarlet at present in use, or fire colour scarlet, formerly Dutch scarlet, and at present universally known by the name of goblin scarlet Thirdly, crimson; and fourthly, madder red. There are also half-scarlet and half-crimson, but these are mixtures of other reds, and therefore should not be considered as particular colours. The red, or *Nacaret de Bourre,* was formerly allowed to be of the good dye; but on account of its want of solidity it was banished by the new regulations. It is natural to suppose that each of these different reds have their particular shades, but it does not therefore follow that they should not be considered as of different classes because the shades of each are perfectly distinct.

Reds are, in one particular, essentially different from blues, as I have observed in the preceding chapter; because reds require a previous preparation. This preparation, as I have before mentioned, is called the *bouillon.* It is generally composed of acids, as sour water, alum, tartar, *aquafortis, aqua-*

regia, etc. These preparations are added in different quantities, according to the shade and colour required. Nutgalls are also frequently used, and sometimes alkaline salts. This I shall explain in the sequel, when describing the manner of working each of these colours.

CHAPTER XII

Of Scarlet in Grain, or Venetian Scarlet

This colour is called scarlet in grain because dyed with kermes, long supposed to be the seed of the tree on which it was found. It was formerly called French scarlet, because, as some people imagine, it was found in France; but it is at present known by the name of Venetian scarlet, being very much used in that country. It has indeed less fire, and is darker than the scarlets at present in fashion; but it has the advantage of being more permanent, and is not so easily spotted.

The kermes of which it is made is a gall-insect which grows, lives, and multiplies on the *Ilex acculeala cocci glandifera*, C. B. P. It is found in the *Garrigues* in the environs of Vauvert, of Vandemian, and of Narbonne; but in Spain, on the coast of Alicant and Valencia, in much greater quantities. As soon as it is gathered every year, the peasants of Languedoc bring it to Montpelier and Narbonne, where they fell it. Those who buy it for exportation, spread it on tiles, and in order to kill the insect which it contains, and which produces a red powder, they sprinkle it with vinegar. This powder is first dried, and then separated from the shell by means of a sieve. The whole is made into large bales, and in the centre of each of these bales they put a certain proportion of the red powder in a leather bag, so that every purchaser may have a part. These bales are generally sent to Marseilles, from whence they are conveyed to the Levant, particularly to Algiers and Tunis, where this ingredient is very much used.

The red drapery of the figures in the ancient tapestry of Brussels and other manufacturing parts of Flanders is dyed with it; and the colour, though two hundred years old, has scarce lost any of its vivacity. This ingredient is scarce ever employed but for the worsted intended for tapestry, and is used in the following manner:—

The wool should be first drenched; for which purpose you put half a bushel of bran into a copper, with a quantity of water sufficient for twenty pounds of wool, which to the best of my knowledge is the usual batch for one dyeing. In this liquor it should boil for half an hour, stirring it from time to time, after which it is taken out and drained. I shall observe, once for all, that when you dye worsted you put a rod through each skein, which commonly weighs about a pound, and which should be kept on the rod during the whole process, by which means the skein is prevented from tangling. It is also convenient for turning the skein, in order to dip each part, that the whole may be equally coloured; for which purpose you raise it about half-way out of the liquor, and holding the rod with one hand, you pull the skein with the other so as to let the part which before was next the rod fall into the liquor. If the worsted should be too hot for the fingers it may be done by means of another rod. The equality of the colour depends so entirely upon the frequency of this manœuvre that it cannot be too strenuously urged. In order to drain them you rest the ends of the rods just mentioned on two poles, which, as I have already said, should be fixed in the wall over the copper.

While the worsted is draining, after being thus drenched, you prepare a fresh liquor, viz. by throwing out what remained in the copper and replenishing with fresh water; to this you add about a fifth part sour water, four pounds of Roman alum, grossly pounded, and two pounds of red tartar. As soon as it boils the worsted on the rods should be immersed for two

hours, almost continually moving the rods, one after another, as I have before directed.

It is necessary to observe that after the alum is put in, when the liquor is ready to boil, it will sometimes rise suddenly out of the copper, if you do not mind to check the boiling by throwing in cold water. If, when it is ready to boil, you put in the cold worsted quickly, it will have the same effect. It is also proper to observe that when dyers work in the *great* they should have their legs bare, that the hot liquor may not rest in the stockings. When the quantity of tartar is rather considerable, as in the present operation, the liquor does not rise so high; but when there is nothing besides the alum, sometimes, when it begins to boil, half of the liquor boils over, unless prevented by the above precautions.

When the worsted has boiled in this liquor for two hours, drained, lightly squeezed, and put into a linen bag, it is deposited in a cool place for five or six days, and sometimes longer; this is called *leaving the worsted in the preparation.* This delay helps it to penetrate, and increases the action of the salts; for as a part of the liquor constantly evaporates, it is clear that what remains, being more impregnated with the saline particles, becomes more active; that is to say, provided there remains a sufficient degree of moisture, for the salts being once crystallised and dry, their power is destroyed.

I am much more explicit concerning this preparation and the manner of making it than I shall be hereafter, because for many colours the quantities are pretty nearly the same. Hence I shall content myself in future with mentioning it slightly, observing only the different quantities of alum, tartar, sour water, or other ingredients.

When the worsteds have remained in this state for five or six days, they are then in a proper condition for being dyed. A fresh liquor is then prepared, according to the quantity of

the worsted, and when it grows warm, if you want a full scarlet, you throw into it twelve ounces of pounded kermes to every pound of worsted; but if the kermes be stale it will require pound for pound. When the liquor begins to boil the worsted should be put in, being still moist; but if it has been suffered to grow dry after boiling, it should be put into warm water and well drained.

Before you put the wool into the copper with the kermes it were advisable to throw in a small handful of refuse wool, which being boiled for a moment imbibes a part of the blackness and dross of the kermes, so that the wool afterwards dyed takes a much more beautiful colour. You now dip the skeins on the rods in the same manner as in the preparation, continually stirring them, and giving them air from time to time, one after another. In this manner they should be kept boiling for a full hour. They are then washed and drained.

If you would reap any advantage from the dye still remaining in the liquor, you may dip a little prepared wool, which will take a colour in proportion to the goodness of the kermes, and to the quantity which had been put into the copper.

If you mean to dye a number of shades, one darker than another, you require much less of the kermes; seven or eight pounds being sufficient for twenty pounds of prepared wool. You then dip the quantity of worsted intended for the lightest shade, leaving it in the copper no longer than necessary, in order to turn it, that it may imbibe the colour equally. It is then raised upon the pegs, and the next shade immediately put in, and suffered to remain for a longer time. You proceed in this manner to the last shade, which should also remain till it has acquired the colour you desire.

You begin with the lightest colour, because if the wool was suffered to remain in the copper longer than necessary, it would be no loss, provided you reserve this batch for the darker shade:

whereas by beginning with the darkest you would have no remedy in case of any accidental skip in the light shades. The same precaution is necessary in regular shades of all colours; but of the colour in question these are seldom made, because the dark shades are not much in use; and as the operation for all colours is the same alike, what I have said respecting this will answer for all the rest.

When the wool has been dyed in this manner, and before it is carried to the river, you may swill it in warm water, with a small quantity of soap well dissolved; this adds a brightness to the colour, but at the same time gives it a little of the *rose*; that is to say, a crimson tint. As I shall in the sequel of this treatise, especially when speaking of reds, frequently make use of the terms *roser* or crimsoned, and *aviver*, or brightened, it is proper to explain what I mean by these words.

Roser, crimsoned, as I have just said, is to give to red a crimson tint; that is, rather a violet cast. Soap and alkaline salts, such as lixivium of potash, lime, etc., crimsons the red in such a manner that thus you may give them, when too bright, what shade you please.

Aviver, to brighten, is quite a different process. It is effected by means of acids, such as red and white tartar, cream of tartar, vinegar, lemon juice, or *aquafortis*. More or less of these acids are used according as you would have the colour more or less brightened. If, for example, in the present case you would give scarlet in grain a flame colour, or make it more like common scarlet, it requires only to throw into the liquor, after the kermes have boiled, a little of the scarlet composition which shall be mentioned hereafter. The dark colour of the liquor is immediately brightened by the acid, and becomes more lively the wool dyed in it has more of the orange, but at the same time is more liable to spot. The cause of which will be seen in the chapter on the "Scarlet of Gobelins."

In order to render this colour more bright and beautiful than common, I have tried a great number of experiments, but could not obtain a red equal to that produced by cochineal. Of all the liquors for the preparation of wool, that which succeeded the best was made according to the proportions I have mentioned. By changing the natural tinge of the kermes by various kinds of ingredients, metallic solutions, etc., various colours may be obtained, which I shall presently mention.

One word only concerning the dyeing of stuffs the above-mentioned red, for it is impossible to prescribe any proportions for an ell of stuff, considering the infinitive variety of their breadth and even of their thickness, and the quantity of wool in their fabrication; experience is the best guide. Nevertheless, if you choose to be exact, the surest way is to weigh the stuff to be dyed, and to diminish about one-quarter of the colouring ingredients prescribed for worsteds; because the stuffs take internally less colour, as their texture, being closer, prevents it from penetrating; whereas the worsted or woollen fleece takes the colour internally as easily as on the exterior surface.

The alum and tartar used in the preparation for stuffs should also be diminished in the same proportion; neither is it necessary to let the stuffs remain in the preparation as long as the worsted; they may be dyed even the day after they had been boiled.

Woollen fleece dyed in the red of kermes, and to be afterwards incorporated in mixed cloth, or for the manufacture of thick cloths, will have a much finer effect than if dyed with madder. I shall speak of this in the description of colours in which kermes are used, or at least where it ought to be preferred to madder, which is nothing like so beautiful, but which being much cheaper is almost universally used.

A mixture of half kermes and half madder is called scarlet

in *half-grain.* This mixture gives a colour extremely permanent, but not so lively, inclining rather to a blood colour. It is prepared and worked precisely in the same manner as if kermes alone were used; only that in the liquor they put but half this grain, the other half is supplied by madder. This is consequently much cheaper, and it frequently happens that the dyers who make it, render it much less beautiful than it might be, by diminishing the quantity of the kermes and increasing that of the madder.

From the trials made on scarlet in grain or scarlet of kermes, both by exposing it to the sun and by various liquors, it is proved that there does not exist a better nor a more lasting colour. It may for solidity be compared to the blues already mentioned. Nevertheless the kermes is scarce ever used except at Venice, for since the fiery scarlets are become the taste, this colour is almost entirely exploded. It has, notwithstanding, many advantages over the other, as it neither blackens nor spots, so that should the stuff get greased, the spot may be taken out without impairing the colour. Nevertheless kermes is so little known to the dyers, that when I wanted a certain quantity for the above experiments, I was obliged to have it from Languedoc; the merchants of Paris encumber themselves with no more than what they vend for the use of medicine.

When a dyer is obliged to dye a piece of cloth of the colour called scarlet in grain, as he neither knows what kermes are nor how to use them, he does it with cochineal, as I shall explain in the following chapter. This is much more expensive and less permanent than that obtained from the kermes. Worsted designed for tapestry is coloured in the same manner; but as this colour is rather difficult to hit with the cochineal, they frequently mix it with Brazil wood, an ingredient hitherto considered as false, and permitted only in colours not in grain. These colours consequently fade in a very short time, and

though they may at first appear ever so lively, they frequently lose all their brightness in less than a year. It were therefore much to be wished that the use of kermes were re-established. Any dyer, by adopting its use, would certainly obtain many colours with more ease and less expense. Besides, his colours being much better and more durable, he would in all probability establish a much greater reputation. I have with the kermes made fifty experiments, which may be useful in practice, but shall mention those only which produced the most remarkable colours. From kermes with cream of tartar, without alum, and with as much of the composition as is used for cochineal scarlet, you obtain in a single vat a very bright cinnamon colour; for this mixture containing acids only, the red particles of the kermes are so attenuated as to be almost invisible. But were this cinnamon to be dipped in a solution of Roman alum, the red would in part reappear, whether because the addition of the alum had expelled a part of the acid of the composition, or whether the earth of the alum, being precipitated by the stringency of the kermes, whose effect is similar to that of galls, reunites the red particles before dispersed, and with them adheres to the wool. Be it as it may, the red by this means recovered is not fine.

With cream of tartar, the composition for scarlet, and a greater quantity of alum than tartar, kermes gives a lilac colour, varying according to the proportion of these ingredients.

If instead of alum and tartar you substitute vitriolated tartar, which is a hard salt produced by a mixture of the acid of vitriol and a fixed alkali, such as oil of tartar and lixivium of potash, etc., and having the kermes boiled in the solution of a small quantity of this salt, the stuff be immersed and suffered to boil for one hour, you may obtain an agate grey colour, tolerably fine, with a reddish cast; for the acid of the composition having too much divided the red of the kermes,

and the vitriolated tartar not containing the earth of alum, it could not in precipitating collect the red atoms which have been dispersed. But this agate grey is permanent, for as I have said in the chapter on indigo, vitriolated tartar is a hard salt which will neither calcine in the sun nor be dissolved by rain.

Glauber salts entirely destroys the red of the kermes, and produces an earthy grey, unable to withstand the trials, because this salt neither resists cold water nor the power of the sun, by which it is reduced to powder.

Green or blue vitriol, separately substituted instead of alum, but employed with crystal of tartar, destroys in like manner the red colour of kermes, which in these two experiments produces the same effect, as it would with nutgalls or sumach; because it precipitates the iron of the green vitriol, which gives the cloth a brownish grey, and the copper of the blue vitriol, which gives an olive tinge.

Concerning blue vitriol, I substitute a solution of copper in *aquafortis*; this also produces an olive colour, a certain sign that kermes possess the precipitating quality of galls.

Why the red of kermes is as permanent as that of madder, is probably because this insect being nourished on an astringent shrub, the juice of this plant has, notwithstanding the alteration which digestion in the stomach of the insect may have produced, preserved its astringency, and consequently the power of giving greater elasticity to the pores of the wool, in order to make them contract more speedily and vigorously when taken out of the boiling water and exposed to the cold; for I have observed that all the barks, roots, woods, fruits, and other substances possessing an astringent quality, give a permanent colour.

The white vitriol of Goslar, whose basis is zinc, as mentioned in my memoir on this semi-metal, of the year 1735, being employed with crystals of tartar, changes the red of the kermes

to violet. Thus with a single colouring drug and a simple alterant, violet colours may be produced without previously giving them a basis of blue. For this compound colour, or considered as such (because hitherto impossible to be procured without the application of blue on red, or red on blue), succeeds also with cochineal, or even with madder, as will appear when I mention these two colours. As white vitriol is procured from a mineral containing lead, arsenic, and various of other substances, whose recrements being fused with sand and alkaline salts, is vitrifyed into a blue mass called sapphire, I suspected that the white vitriol might contain a portion of this blue which changed the red of kermes to violet, and that consequently the bismuth mineral, which really contains this blue substance, and the bismuth itself would produce an effect similar to that of the white vitriol. It will presently appear that I was not mistaken in my conjecture, for having thrown some of the extraction of the bismuth mineral on the experimental liquor, which I made with kermes, and a solution of bismuth itself into another decoction of the same ingredient, they each of them dyed white cloth a violet colour. I shall not in this place give the method of making an extraction from the ore of bismuth, for besides that it is an operation rather difficult for a dyer, this ore is not found in France. It must be imported from Misnia, where they do not part with it so easily. Nevertheless, should the reader be curious to know what I mean by an extraction of the ore of bismuth, he will find the process in the *Memoirs of the Academy of Sciences* for the year 1737, in which there is a paper of mine on sympathetic inks. With regard to the solution of bismuth, which produces nearly the same effect, I make it in the following manner:—I take four parts of the spirit of nitre and four parts pure water mixed together, in which I dissolve one part of bismuth, which I break into small pieces in order to put them into the

liquor by degrees, lest they should produce too violent a fermentation.

Whenever there is too great a quantity of acid added to the liquor of kermes, be it spirit of vitriol, spirit of nitre, or *aqua-fortis*, vinegar, lemon juice, or even sour water, it so perfectly divides the colouring red particles that the cloth acquires only a cinnamon colour with an aurora cast, if there be much acid; and if there be less acid, the colour is rather more red.

Fixed alkalies, with the addition of sour water and cream of tartar instead of alum, do not, like acids, destroy the red of kermes; but if the quantities be too great, they deepen and soil in such a manner that the cloth obtains only a tarnished lilac colour. From other experiments still more varied I procured an infinity of colours, but as there appeared none finer than those produced by ingredients much less expensive than the kermes, I thought a relation of them needless, as it would only extend this treatise to an unnecessary length.

CHAPTER XIII

Of Fire Scarlet

Fire scarlet, formerly known by the name of Dutch scarlet, and at present called scarlet of Gobelins, the discovery of which Kunckel attributed to Kuster, a German chemist, is the finest and brightest colour in the art of dyeing. It is also the most expensive, and one of the most difficult to bring to perfection. It is indeed scarce possible to determine what is the standard of perfection; because, independent of the different tastes by which mankind are divided in their choice concerning colours, there is besides a general taste, which makes some colours fashionable at one time more than other. It is fashion, therefore, which constitutes the perfection of colours. Formerly, for instance, deep unglaring scarlets were generally preferred. The fashionable scarlet at present is tinged with orange, is fiery and dazzling. I shall not at present decide which is the preferable taste, but shall describe the method of obtaining both these colours, with their intermediate shades.

Cochineal, which produces this beautiful colour, and which is called *Mestique* or *Tescale,* is an insect gathered in considerable quantity in Mexico. They are cultivated by the natives of the country; that is to say, they are gathered from the plant by which they are nourished before the rainy reason. Those designed for sale are killed and dried, and the rest are kept in order to multiply when the bad season is over. This insect lives and multiplies on a species of spinous *Opuntia* called *Topal.*

They may be preserved in a dry place for many ages without spoiling. I have a small quantity from Amsterdam undoubtedly one hundred and thirty years old; they are nevertheless as entirely perfect as if they had but just arrived from Vera Cruz, and produce the same effect in dyeing as the fresh cochineal.

The cochineal of *Sylvestre*, or *Campassianne*, is also imported into Europe from Vera Cruz. The Indians gather it in the woods of Old and New Mexico. The insect lives, grows, and multiplies on the uncultivated *Opuntias*, which grows there in great abundance. It is there exposed to all the inclemencies of the rainy season, and dies naturally. This cochineal is much smaller than the cultivated cochineal, and its colour more durable, though less bright: but there is no advantage in using it, for though it is cheaper a greater quantity is required.

Damaged cochineal is sometimes sold at Cadiz, either shipwrecked or, by some mischance, wet with sea water. This sort of accidents considerably lessen the price; for as the tinge of the cochineal is sometimes crimsoned by the sea water, it can only be used for purples, which are not of the finest. There was, however, in the year 1735 a person who possessed a secret of turning it to as much advantage, even for scarlet, as the finest cochineal. The discovery of this secret would not be very difficult; we will not however by making it public deprive him of his expected reward, at a time too when perhaps it may be necessary.

There is scarce a dyer who has not a particular receipt for scarlet, and each of them is prejudiced in favour of his own method. His success, notwithstanding, depends on the choice of the cochineal, the water used for dyeing, and the manner of preparing the solution of tin, called by the dyers the *composition for scarlet*.

As it is this composition which gives a fine bright fire colour to the cochineal, which without the addition of this acid solution

would be crimson, I shall, from my own experience, give the best method of making this composition. I take eight ounces of spirit nitre and weaken it by adding eight ounces of river water; I then dissolve, by degrees, half an ounce of sal-ammoniac, very white, in order to make an *aquaregia*; for it is well known that the spirit of nitre alone is not a proper menstruum for tin. Lastly, I add only two drachms of saltpetre of the third drying; this might be omitted, but I am persuaded that it contributes to blend the colour and make it more uniform. In this weak *aquaregia* I dissolve an ounce of English tin, previously made into grains, by dropping it, when melted, from a certain height into a basin of cold water. These grains I drop into the solution one after another, waiting till the first is dissolved before I put in a second, in order to preserve the red vapours which rises in a great quantity, and which would be lost were the metal to be dissolved too precipitately. It is necessary to preserve this vapour, which, as Kunckel observed in his time, contributed to the vivacity of the colour. This is doubtless a much more tedious method than that used by the dyers, who throw their *aquafortis* immediately on the tin grains, and who, when it produces a rapid fermentation and a quantity of vapour, allay it with cold water. When my tin is thus gradually dissolved, the scarlet composition is complete, and the liquor of the colour of a solution of gold. I use the finest tin, without alloy, such as the first production of the furnaces at Cornwall; consequently there is neither dust nor black sediment at the bottom. This solution of tin, though so very transparent when just made, becomes milky in the violent summer heats. The dyers are almost generally of opinion that it is then turned, and no longer good. I found, however, that this apparent defect made no difference. Besides, in cold weather it resumes its former transparency, provided it be prepared with the several precautions which

I have just directed. I must likewise add that it should be preserved in flasks well stopped with glass stoppers to prevent the volatile parts from evaporating.

The dyers' composition, for want of this attention, is frequently of no use in twelve or fifteen days. I give them the best method, and if they expect perfection they must alter their present defective method.

The dyers have a stone vessel with a wide mouth in which they put two pounds of sal-ammoniac, two ounces of saltpetre refined, and two pounds of tin granulated in water; they put into a separate vessel four pints of water, half a pint of which they throw on the mixture in the stone vessel. They afterwards add a pound and a half of common *aquafortis,* which produces a violent fermentation; when the ebullition ceases they add as much more *aquafortis,* and immediately afterwards another pound. After this they pour on it the remainder of the four pints of water. They cover the vessel well, and let it stand till the next day. The saltpetre and sal-ammoniac may be dissolved in *aquafortis* before the tin is added; but this they say is the same thing, though it is very certain that the last is the best method. Others mix the water and *aquafortis* together, which mixture they throw on the tin and sal-ammoniac. Others, in short, observe different proportions.

The day after preparing this composition they make the *preparation* for scarlet, not in the least resembling that mentioned in the preceding chapter. As for example, for one pound of worsted they put into a small copper ten gallons of clear river water. When the water is a little more than warm, they add two ounces of cream of tartar in fine powder, and a drachm and a half of pulverised cochineal sifted. They keep a quick fire, and when the liquor is ready to boil, add two ounces of the composition, which acid immediately changes the colour of the liquor from crimson to blood colour. As soon as the

liquor begins to boil they plunge the worsted, previously steeped in hot water, and expressed. It is then stirred without ceasing, and suffered to boil during an hour and a half; after which it is taken out, gently squeezed, and washed in cold water. The worsted when taken out is of a tolerable bright flesh colour, or even some shades darker, according to the goodness of the cochineal and the strength of the composition. The colour of the liquor is so entirely imbibed by the worsted that it remains almost as clear as common water. This is called the scarlet boiling, a preparation absolutely necessary, and without which the cochineal dye would not hold.

In order to finish there must be another preparation of very clear water, as the goodness of the water is of infinite consequence to the perfection of scarlet. They add at the same time half an ounce of starch, and when the liquor is better than warm, six drachms and a half of cochineal, also pulverised and sifted, is added to it. Two ounces of the composition is poured into the liquor a litttle before it boils, which, as at first, immediately changes colour. You wait till it begins to bubble, and then dip the worsted. It should be constantly stirred as at first, and in the same manner suffered to boil for an hour and a half; after which it is taken out, expressed, and rinsed at the river: the scarlet is then in perfection.

One ounce of cochineal to a pound of wool will give it a fine colour, and make it sufficiently deep, provided it be managed with attention according to my directions, and that there remains no colour in the liquor. If, nevertheless, you would have it deeper, you may add a drachm or two more of the cochineal; but a greater quantity would destroy all its brightness and vivacity.

Though I have ascertained the quantity of the composition, as well for the preparation as for dyeing, this quantity should not be considered as invariable. The *aquafortis* generally

used by the dyers is seldom of an equal strength ; consequently if it be always mixed with an equal quantity of water, it will not always produce the same effect. There are certainly some methods of ascertaining the different degrees of the acidity of the *aquafortis*, as, for example, to use that only two ounces of which will dissolve one ounce of silver : by observing this method you might succeed in making a composition that would be always the same ; but then the quality of the cochineal would occasion other varieties ; however, the little difference which this generally produces in the scarlet shade is not of much consequence ; besides, there is a method of remedying this defect, and bringing it precisely to what colour you please.

If the composition be weak, and less of it be added than I have directed, the scarlet will be rather deeper and stronger ; but if, on the contrary, there be a little too much, it will have more of the orange colour ; more of what is called fire. In order to give it this shade a little more of the composition may be added after the first, if the worsted appears to have imbibed too deep a colour. But the wool should be taken out first, and the composition well stirred in the copper, for if it happens to touch the wool before it be well mixed, it would spot. If, on the contrary, the scarlet be too fiery, too much on the orange, or too rusty, there is nothing to be done ; but when it is entirely finished, to dip it in hot water : this will crimson it a little, that is, it will diminish the brightness of the orange ; but if this is not found sufficient it will be necessary to put a little Roman alum into the hot water.

When you would dye a regular series of scarlet shades in worsteds, half the quantity of cochineal and of the composition used for a full scarlet will be sufficient : you also diminish in proportion the cream of tartar in the preparation. The worsted should be divided into as many skeins as you would have shades, and when the preparation is made you dip the

skein intended for the lighest shade, which should remain but a very little time; the next shade should afterwards be put in, and suffered to remain some little time longer, and so on to the darkest shade; the worsteds are then washed, and the liquor prepared, in order to finish them. As soon as the liquor is in a proper state, every shade is dipped one after another, beginning with the lightest. If you perceive any skip in the shade, the skein which appears deficient in colour should get another dip. This deficiency is easily perceived, and a very little practice enables you to sort them perfectly.

One circumstance in the art of dyeing which deserves attention, but which I have not yet mentioned, is an inquiry concerning the materials of which the cauldron is made—dyers are divided in this particular. Their cauldrons in Languedoc are made of fine tin. They are also used by several dyers at Paris; but Mr. Julienne, whose scarlet is very highly esteemed, makes use of brass cauldrons. These are also used in the dyeing manufactory of St. Dennis. Mr. Julienne is careful only to suspend a large packthread net, with pretty small meshes in his cauldron, to prevent the stuff from touching. At St. Dennis, instead of a net they use a large open wicker basket; but this is less convenient than the net, because it requires a man at each side of the copper to keep it even and to prevent it, when loaded with the stuff, from rising to the surface of the liquor.

This practice, so different with regard to the materials of the cauldron, determined me to make an experiment. I took two ells of white Sedan cloth, which I dyed in two cauldrons, one of copper furnished with a packthread net, and the other of tin. I weighed the cochineal, the composition, and other ingredients with as much accuracy as possible. They boiled exactly the same time. In short, I was sufficiently attentive to make the operation the same in every particular, that

in case of any perceptible difference it could only be attributed to the different materials of the cauldrons. After the first boiling the two patterns were absolutely alike, except that the piece done in the tin cauldron was rather more marbled, and not quite so even as the other; but this in all probability might be occasioned by their not having been equally cleansed at the mill. I finished each piece in its proper cauldron, and they were both of them very beautiful. Nevertheless it was very evident that the cloth which had been dyed in the tin was more fiery, and the other rather more crimsoned. They might have been easily brought to the same shade; but this was not my object. From this experiment it appears that with a copper cauldron the quantity of the composition should be increased; but then the cloth grows harsh to the feel. Those who dye in copper, to prevent this evil add a little of the turmeric, which is a drug only used for false colours, and therefore prohibited by the *Regulations* to dyers in grain, but which gives scarlet that dazzling fiery colour so much the fashion at present. It is, however, if you have any suspicion, easy to discover the deception by cutting the pattern with a pair of scissors. If it has no turmeric the cut edge will appear white, otherwise it will be yellow. When the close texture is equally dyed with the superficies, let the colour be what it will, they say the colour *cuts*, and the contrary when the middle of the texture remains white. Legitimate scarlet never cuts. I call it legitimate, and the other false, because that with the addition of the turmeric is more liable to fade. But as the taste for colours is so variable, as the bright scarlets are at present the mode, and as it is necessary in order to please the buyer that it should have a yellow cast, it were better to authorise the use of the turmeric, though a false colour, than to allow too large a quantity of the composition by which the cloth is injured, being more liable not

only to dirt, but also to tear, as the fibres of the wool are rendered brittle by the acid.

I must also add that a copper cauldron should be kept extremely clean. I have myself frequently failed in scarlet patterns by neglecting to clean the cauldron. I cannot in this place forbear condemning the practice, even of some eminent dyers, who at about six o'clock in the evening make their preparation in a copper cauldron, and in order to gain time keep it hot till daylight the next morning, when they dip their stuffs. The preparation must undoubtedly corrode the copper during the night, and consequently by introducing coppery particles into the cloth, injure the scarlet. They will tell us that they do not put in the composition till immediately before the cloth is dipped ; but this is no apology, for the cream of tartar added on the preceding evening, being sufficiently acid to corrode the copper, forms a verdigris which dissolves, it is true, as soon as it is formed, but which nevertheless produces the same effect.

As tin is absolutely necessary in the scarlet dye, it were much better to have a cauldron of this metal, which would infallibly contribute to the beauty of the colour. But these cauldrons, if sufficiently large, cost three or four thousand livres, an object of consideration, especially as they may melt in the first operation, if not carefully attended to by the workmen. Besides it would be very difficult to cast a vessel of so large a size without flaws that would require to be filled. It is absolutely necessary that they be made of block tin. If the flaws should be filled with solder which contains a mixture of lead, many parts of the cauldron will retain the lead, which, being corroded by the acid composition, will tarnish the scarlet. Hence there are inconveniences in every particular. Nevertheless, if it were possible to procure a skilful workman capable of casting a cauldron of the Melac tin without flaw, it were

certainly preferable to every other; for though the acid of the composition should in some parts corrode it, the detached particles will do no harm, as I have already observed.

There is no danger of melting a tin cauldron but when it is emptied in order to fill it with a fresh liquor; I shall therefore add the precautions necessary to prevent this evil. In the first place the fire should be taken entirely from the furnace, and the remaining embers quenched with water. Part of the liquor should then be taken out with a bucket, while the remainder should be dashed about with a shovel by another person, in order to keep the upper part of the cauldron continually moist, at the same time cooling what remains in the cauldron with cold water. In this manner it should be continued till you can touch the bottom without being burnt. It should then be entirely emptied and all the sediment taken up with a moist sponge. This attention will preserve your cauldron.

Having given the method of dyeing worsteds in scarlet, and of making the shades required for all kinds of tapestry, I shall now add the method of dyeing several pieces of stuff at the same time, and shall in this place describe the practice used in Languedoc, as it was communicated to me by M. de Fondieres, then inspector-general of the manufactories. I made the experiment myself with several ells of stuff, and succeeded perfectly well, though the colour was not quite so fine as the scarlet of Gobelins.

It is first necessary to observe that woollens are never dyed scarlet in the fleece, for the two following reasons. The first is, or ought, to regard all stuffs of simply one colour; those of many colours are called mixed stuffs. These kind of stuffs are never dyed in the wool, especially when the colours are bright and fine; because in the course of the fabrication the spinning, twisting, or weaving, it would be almost impossible to prevent some white or other colour wool from mixing, which

though ever so trifling would injure the stuff. For which reason reds, blues, yellows, greens, or any of these unmixed colours, should not be dyed till after they have been manufactured.

The second reason is peculiar to scarlet, or rather to the cochineal, which, being heightened by an acid, cannot stand the fulling without losing much of its colour, or being at least excessively crimsoned. For the soap, which contains an alkaline salt, destroys the vivacity produced by the acids. Hence it is evident that neither cloth nor stuffs should be dyed scarlet till they have been fulled and dressed.

For example, in order to dye five pieces of Carcassonne cloth at the same time, each piece five quarters broad and fifteen or sixteen ells in length, it is necessary to observe the following proportions:—You begin by making the composition in a very different manner from the preceding process, viz. twelve pounds of *aquafortis* put into a stone jar or glazed vessel, with twenty-four pounds of water and one pound and a half of tin grains added. The solution goes on more or less slow according to the acidity of the *aquafortis*, and should stand for twelve hours at least. During this time a kind of blackish dirt falls to the bottom; the top should be then drained off the sediment: this liquor is of a clear lemon colour, and is preserved by itself. This process evidently differs from the first by the quantity of water mixed with the *aquafortis*, and by the small portion of tin, of which scarce any remains in the liquor, for the *aquafortis* not being in itself a solvent for tin, only corrodes and reduces it to a calx, provided neither saltpetre nor sal-ammoniac be added, which would convert it into an *aqua-regia*. The effect of this composition is not, however, different from others, and is perceptible to those who from experience are competent judges of this colour. The composition without sal-ammoniac has been for a long time used by the manu-

facturers of Carcassonne, who doubtless imagined that its effect was owing to a supposed sulphur of tin, and may be preserved from putrefaction for thirty hours in winter and only twenty-four in summer. It then grows turbid, forms a cloud, which falls to the bottom of the vessel in a white sediment. This sediment is a small portion of the tin which was suspended in an acid not prepared for the solution. The composition, which ought to be yellow, becomes clear as water, and if employed in this state never succeeds, but produces the same effect as if it had been milky. The late Mr. Barron pretended to be the first at Carcassonne who made the discovery that sal-ammoniac was necessary to prevent the tin from precipitating. Hence it follows that there was not in this city a creature who knew that *aquaregia* is the only actual solvent for tin.

When the composition is prepared as I have now described, according to M. de Fondieres, you put, for the quantity of cloth last mentioned, about sixty cubic feet of water into a large copper; when the water grows warm you add a sackful of bran: it is sometimes necessary to use sour water; they will either of them do, as they say, to correct the water, viz. to absorb the terreous and alkaline substances, which, as I have already said, crimson the tinge of the cochineal. We should be well informed concerning the nature of the water employed, in order to know whether these correctives be necessary.

Be it as it may, when the water is a little more than warm, you add ten pounds of crystals or cream of tartar pulverised; that is to say, two pounds to each piece of cloth. The liquor should be then violently stirred, and when rather hot you should put into it half a pound of the powder of cochineal, mixing it well together, and immediately afterwards you pour into it twenty-seven pounds of the composition, very clear, which also requires to be well stirred. As soon as it begins

to boil, the cloth being immersed, should boil very fast for two hours, and during that time should be kept in continued motion on the winch, and when taken out passing it through the hands by the lifting, in order to open and give it air. It is afterwards carried to the river and well washed.

In order perfectly to understand the method of stirring the cloth it is requisite to recollect what has been said in the beginning of this work, viz. that a kind of reel or winch, with a handle for turning, should be placed horizontally on the iron hooks which are fixed in the felloes that support the edge of the cauldron. You first join the several ends of each piece of stuff to be dyed at the same time, and as soon as they are immersed you carefully keep the end of the first piece in your hand; you then lay it on the reel, which should be turned till the end of the last piece appears. It is then turned the contrary way, and in this manner every piece will be dyed as even as possible.

When the cloth has been well washed the cauldron should be emptied, fresh liquor prepared, to which you must add, if necessary, a sack of bran or some sour water; but if the quality of the water be very good there is no occasion for any addition. When the liquor is ready to boil, you put in eight pounds and a quarter of cochineal pulverised and sifted. The whole is then mixed together as even as possible; but when you cease to stir you must mind when the cochineal rises to the surface, forming a kind of scum the colour of lees of wine. As soon as this scum begins to divide you pour in eighteen or twenty pounds of the composition. You should have a vessel full of cold water near the cauldron ready to throw in, lest after putting in the composition it should rise above the edge, as is sometimes the case.

When the composition is put into the copper, and the whole well mixed, you turn the winch quick for two or three turns,

that every piece may imbibe the cochineal equally. It is then turned more slowly in order to let the water boil. It should boil very fast for two hours, constantly turning and keeping the cloth down with a stick. The cloth is then taken out and passed through the hands by the listing, in order to give it air and to cool it; it is afterwards washed at the river, dried, and dressed.

Hence it appears that for every piece of Languedoc cloth designed for the Levant, is required a pound and three-quarters of cochineal. This quantity is sufficient to give the cloth a very fine colour; but if you increase the quantity of cochineal, and still require an orange tint, you must necessarily increase the quantity of the composition, which would injure the cloth without improving the colour.

There is a considerable advantage in having a great quantity of stuff to dye at the same time; as for example, when the five first pieces are finished, there remains a certain quantity of the cochineal, which, supposing seven pounds at first, might amount to twelve ounces, so that cloth put into this second liquor will imbibe the same shade of rose colour as if you had coloured a fresh liquor with twelve ounces of cochineal. The quantity remaining may, however, vary very much according to the quality of the cochineal, or according to the fineness of the powder; but I shall speak of this more particularly before the conclusion of this chapter. Though the quantity of colour remaining in the liquor may be very inconsiderable, it nevertheless deserves attention on account of the dearness of this drug. Of this liquor, therefore, a preparation may be made for five pieces of cloth, and it will require less of the cochineal and less of the composition, in proportion, as near as you can guess, to the quantity remaining in the liquor. This is also a saving of wood and time; but it is impossible to give positive directions concerning this manœuvre, which must

be left to the ingenuity of the dyer ; for having dyed rose colour after the scarlet, you may make a third preparation, which will dye a flesh colour. If there is not time to make these two or three preparations in twenty-four hours, the liquor spoils. Some dyers put Roman alum into the liquor to prevent it from spoiling, but this changes it to a crimson.

Scarlets thus crimsoned in the same liquor in which they had been dyed are never so bright as those done in a fresh liquor. Drugs which reciprocally destroy each other's effect, are more efficacious when employed in succession.

When you dye cloth of different qualities, or any kind of stuffs, the best method is to weigh them, and for every hundred pounds to allow about six pounds of crystals or cream of tartar, eighteen pounds of the composition in the preparation, the same quantity in the completion, and in each of them six pounds and a quarter of cochineal. For the accommodation of those who would themselves make small experiments, the whole may be reduced, viz. one ounce of cream of tartar, six ounces of the composition, and an ounce of cochineal for every pound of stuff. Some of the Paris dyers succeed very well by putting two-thirds of the composition and a quarter of the cochineal in the preparation, and the remaining third of the composition and the other three-quarters of the cochineal to the completion.

It is not the custom to put crystal of tartars in the finish ; I am, however, convinced by experience that it does no harm, provided that at most you put but half the weight of the cochineal, and in my opinion it made the colour rather more permanent. There have been dyers who have dyed scarlet at three times. In this case they had two preparations, and afterwards the finish ; but they always used the same quantity of drugs.

I observed in the preceding chapter that the kermes were so little used for brown or Venetian scarlets, that these kind

of colours were made with cochineal. For this purpose the preparation is made as usual, and for the dyeing they add to the liquor eight pounds of alum to every hundredweight of stuff. This alum is dissolved in a separate cauldron with a sufficient quantity of water; it is thrown into the liquor before the cochineal. The remainder is done precisely the same as in common scarlet: it gives the cloth the colour of Venetian scarlet; but it is not by any means so permanent as the colour obtained from kermes.

There are no alkaline salts that do not crimson scarlet; but it is more generally the custom to use alum, because these alkaline salts are no addition to the permanency of the colour, and may possibly injure the stuffs, because all animal substances are dissolved by fixed alkalies. The alum, by being deprived of its phlegm by calcination, will more certainly crimson. The liquor which had been used for crimsoning is red, and still redder in proportion as the scarlet is more crimsoned, so that the colours part with much of their basis in the liquor by which they are darkened. It is, however, impossible to darken in grain without salts. The late Mr. Barron, in a memoir which he presented to the Royal Academy of Science twelve or fifteen years ago, remarks that he succeeded better with the salt of urine than with any other salt for uniting the colour and preserving its brightness and fulness; but, as he observed, it is very inconvenient to make any quantity of this salt.

I said in the beginning of this chapter that the choice of the water for dyeing scarlet was of importance; the greatest part of the common waters sadden, because they almost always contain a quantity of stony or calcareous earth, and sometimes of sulphureous or vitriolic acid. These are commonly called hard waters. By this term they mean water that will not dissolve soap, and in which it is not easy to dress vegetables. By absorbing or precipitating these heterogeneous substances,

all waters are rendered equally good. If the matter be alkaline, a little sour water will produce this effect. Five or six cubic feet of this sour water added to sixty or seventy cubic feet of other water before it has boiled, will cause the alkaline earth to rise in a scum, which may be easily taken off the liquor. A sackful of any kind of white mucilaginous root cut in small bits, or, if dry, powdered, will also, if the sack be left to soak in the water for a half or three-quarters of an hour, correct a doubtful water; bran, as I have said above, will also answer the same end tolerably well.

What I have hitherto said in this chapter is meant for the instruction of those who would acquire knowledge in the art of dyeing. I shall now endeavour to satisfy the philosopher, and present him with the experiments by which I discovered the invisible mechanism, if I may be allowed the expression, of these various preparations.

Cochineal infused, or boiled only in clear water, yields a purplish crimson, which is its natural colour. Put this solution into a glass and drop on it some spirit of nitre; it will gradually become lighter till it is almost yellow. Add a few drops more, and scarce any of its original redness will remain. In this manner acids destroy red, by dissolving and dividing it into particles of such tenuity as to become imperceptible. By substituting vitriolic acid instead of nitrous acid, the first alteration in the colour will be purple, then purple lilac, afterwards light lilac, then flesh colour, and then no colour at all. The bluish tinge, which by mixing with a red constitutes purple, may proceed from that small portion of iron from which oil of vitriol is very rarely exempt. Cream of tartar is the only salt used in the preparation for scarlet, without the addition of alum, as is common in the preparation for other colours, because its vitriolic acid would crimson the dye.

It is nevertheless necessary to have a white earthy substance;

a lime which, with the red particles of the cochineal, may form a kind of painter's lacquer, and which by the help of crystals of tartar is introduced into the pores of the wool. This calx is obtained from a solution of pure tin. Let this experiment be made in a small glazed earthen vessel, and when the cochineal has tinged the water the composition should be dropped into it drop by drop, examining, with a magnifying glass, the effect produced by each drop. You perceive a small circle, whence arises a pretty brisk fermentation. The calx of the tin separates, and is immediately dyed the same lively colour which is imbibed by the cloth in the sequel of the operation.

It is evident that the calx of tin is necessary in this operation, because if the cochineal is used with spirit of nitre, or *aqua-fortis* only, it produces a very ugly crimson. If you dissolve any other metal in the spirit of nitre, such as iron or mercury, the first will produce a deep ash colour; and the second a maroon colour, without the least appearance of the red of the cochineal in either of them. Hence it is rational to suppose that the calx of tin, having been dyed by the colouring particles of the cochineal, enlivened by the dissolving acid of this metal, has formed this kind of terreous lacquer, the atoms of which are introduced into the pores of the fibres of the wool which were opened by the heat of the boiling water; they are there wedged in by the crystals of tartar, and the pores of the cloth being immediately contracted by the sudden cold when exposed to the air, the colouring particles will be sufficiently fixed to be termed in grain. If, by being exposed to the air afterwards it should lose any of its former vivacity, it will not suffer alike in all places, but according to the heterogeneous substances with which the air is impregnated. In the country, for example, and particularly in a high situation, a scarlet cloth will preserve its beauty much longer than in a large city abounding with urinous and alkaline effluvia; for it is well known, as I have

before observed, that all alkaline substances destroy the effect produced by an acid on any colour whatsoever. For this reason, if you boil a piece of scarlet in a lixivium of potash the colours become purple, and by continuing to let it boil is entirely discharged; because fixed alkali and crystals of tartar produce a soluble tartar which water dissolves and easily detaches from the pores of the wool. The entire mastic of the colouring particles being thus destroyed, is mixed with the lixivium of the salts.

I have tried several different experiments with the cochineal colour, in order to try the effect of its union with substances which are generally supposed not colouring; but I shall relate those only which produced the most extraordinary effects.

For example, zinc dissolved in spirit of nitre converts the red of cochineal into a violet slate colour.

Sugar of lead, instead of crystals of tartar, produces a tarnished lilac, which shows that the leaden particles unite with the colour of the cochineal.

Vitriolated tartar, made with potashes and vitriol, destroys the red of this ingredient, and leaves only an agate grey.

Bismuth dissolved in spirit of nitre, diluted with an equal quantity of water poured on the cochineal liquor, gives cloth a beautiful bright turtle-grey colour.

A solution of copper in spirit of nitre, not diluted, gives with the cochineal a dirty crimson.

That of silver, a cinnamon colour.

Arsenic, a more lively cinnamon than the preceding.

A solution of gold in *aquaregia* produced a streaked maroon which makes the cloth appear as if it had been manufactured with different coloured wool.

A solution of mercury in spirit of nitre produces nearly the same effect.

Glauber salts only, mixed with the cochineal liquor, destroys

the red in the same manner as vitriolated tartar, and, like it, produces an agate grey colour; but not in grain, because this salt is too easily dissolved, even by cold water, and is also of the class of salts which are easily calcined by the air. Fixed salt of urine produces a clear ash colour, without the least appearance of red, and like the preceding article is not in grain, because it yields no permanent mastic, and consequently is dissolved by the humidity of the air only. Finally, the extract of bismuth changes the red of cochineal to a violet colour, as fine as if the cloth previous to the application of red had been dyed an azure blue.

From these experiments it is easy to conclude that the salts and metallic solutions unite with the particles of the colouring ingredient, and it is also demonstrable that the addition of these particles greatly contribute to the tenacity of the colours.

Before the conclusion of this chapter I shall make some observations, which will not, I think, be unacceptable to the reader. Neither the dirt of the street nor many other acid substances will spot scarlet, if immediately washed off with a clean towel and clear water; but if suffered to dry, the spot is then a dark violet colour, and cannot be corrected without a vegetable acid, such as vinegar, lemon juice, or a weak solution of white tartar made hot; but these acids, if not managed with care and dexterity, will, in taking out the dark spot, leave a yellow one. I have before observed that acids will rust and destroy even the red of cochineal. A red cloak extremely spotted with dirt may be cleaned with sour water. For some kinds of spots it is necessary to dip the stuffs in the liquor that remains after dyeing scarlet; but for others you are obliged to discharge the colour and dye it again.

Alkalies have not alone the property of discharging the scarlet colour. A piece of scarlet cloth put into the preparation for this colour will be discharged in such a manner that

if it boil but for one hour with three pieces of white cloth it will be difficult to distinguish that which was scarlet from the others.

If you dip a piece of scarlet cloth in the preparation-water it will immediately lose all its colour, because the first salts dissolve and mix with the fresh; but if you boil it again in a cochineal liquor it will recover its first colour, with the addition of superfluous colouring particles; and the cloth will have much less vivacity than it would have acquired in the common operation. Hence it appears that the inventors of this magnificent colour must have made a considerable number of combinations before they attained perfection.

Scarlet cloth always loses a great part of its brightness in the dressing, because it lays the fibres of the nap almost parallel with the weft. In this state the cloth has less superficies, and consequently reflects fewer rays of light. Besides, the ends of the hair is always the most impregnated with the dye, so that when they are laid down by the dressing, their ends not appearing is a great disadvantage to the vivacity of the colour.

CHAPTER XIV

Of Crimson

Crimson, as I have before said, is the natural colour of the cochineal, or rather that which it gives to wool when boiled in alum and tartar, the common preparation for every colour. The following is the method generally practised with worsteds; nor is there any great difference with regard to cloth, as will be shown in the sequel:—You put into a cauldron two ounces and a half of alum and an ounce and a half of white tartar for every pound of wool. As soon as it begins to boil you put in the wool, stirring it well, and suffering it to boil for two hours; it is then taken out, lightly squeezed, and put into a bag, in which it should remain, as for scarlet in grain and for every other colour.

A fresh liquor is prepared for the dyeing, in which you put an ounce of cochineal for every pound of wool. When it begins to boil you put in the wool, stirring it well, as should be done in the preparation, and thus it should remain for an hour; it is then taken out, squeezed, and rinsed at the river.

If you require a regular series of shades you proceed in the same manner as I have directed for scarlets, viz. putting but half the quantity of cochineal. The shades should be dipped one after another; the darker should remain longer than the lighter, beginning always with the lightest shade.

I have made many attempts to bring crimson to greater perfection than has been hitherto done, and have succeeded

so far as to render the grain colour equal in brightness and vivacity to the false crimson. I proceeded on the following principles:—It is very evident, from what has been already said, that cochineal is saddened by alkalies: this was my foundation. I tried soap, pearl ash, and potash; these salts had the desired effect; but at the same time they tarnished and diminished the brightness. I determined to try volatile alkalies, and found that the volatile spirit of sal-ammoniac produced a very good effect; but it evaporated in a moment, so that being obliged to use a considerable quantity, the expense of the dye was vastly increased. I had then recourse to another expedient, which succeeded better, and the expense was very trifling: which was, to use the volatile alkali of sal-ammoniac in the moment of its extraction from its basis. For this purpose, when I had finished after the common process, I dipped my crimson in a new liquor, in which I dissolved a small quantity of sal-ammoniac. When the liquor was a little better than warm, I put in the same quantity of potash, and my wool immediately took a colour very highly crimsoned, and very bright. This method even saves cochineal, which being raised by the fresh solution, less of it will do than is usual in common practice. Several, even eminent dyers, heighten their crimson with *Archil*, a drug of the false dye.

A very beautiful crimson is obtained by boiling the wool, as for common scarlet, and afterwards making a second preparation with two ounces of alum and an ounce of tartar to every pound of wool; it should remain an hour in this decoction. You then immediately prepare a fresh liquor, in which to every pound of wool you put six drachms of cochineal. When it has remained an hour in this liquor it is taken out, and immediately dipped in a solution of *barilla* and sal-ammoniac. You may in this manner make a very beautiful series of shades of crimson by diminishing the quantity of the cochineal. It

is necessary to observe that in this process six drachms of cochineal to every pound of wool is sufficient; because in the first preparation for scarlet they allow a drachm and a half of cochineal to every pound. It should also be observed that in this process your solution of alkaline and ammoniacal salt must not be too hot; because in that case the volatile spirit of the latter would evaporate too quickly, and the crystals of tartar, being then converted into soluble tartar, lose their property.

The same effect may be produced by using the cochineal *Sylvestre*, or *Campassianne*, instead of fine cochineal; nor is the colour inferior, provided you put in a sufficient quantity; for, in general, four parts of cochineal sylvestre has no more effect in dyeing than one part of fine cochineal. You may even employ the cochineal sylvestre in scarlet, but then it should be used with great precaution, and it were even better not to use it but for half-scarlets or half-crimsons. I shall mention this more fully when speaking of these colours in particular.

When scarlet is spotted, either in the operation or by some unforeseen accident, or even when the dye has failed, the common methed is to dye it crimson, which is done by dipping it into a solution containing two pounds of alum to about a hundred pounds of wool. In this it is immediately dipped, where it is suffered to remain till it has acquired the crimson shade you desire.

The following is the present method in Languedoc, where they make a very beautiful kind of crimson cloth which they export to the Levant, but which is not so deeply crimsoned as that I have been mentioning, and which comes much nearer to the Venetian scarlet.

For five pieces of cloth the liquor is prepared as usual, adding bran if necessary. When it is a little better than warm, they add ten pounds of sea salt instead of crystals of tartar; and when ready to boil they pour into it twenty-seven pounds

of the composition for scarlet, made according to the Carcassonne method, without any addition of cochineal. The cloth is kept in the liquor for two hours, keeping the reel constantly turning, and the liquor boiling. It is then taken out, opened, and rinsed at the river; a new liquor is then made with eight pounds and three-quarters of cochineal well pulverised and sifted; when ready to boil you throw into it one-and-twenty pounds of the composition. In this dye the cloth should boil, with the usual precaution, for three-quarters of an hour; after which it is taken out, opened, and washed. It is a very fine crimson, though not very deep. If you require it deeper, you put a good deal of alum into the first liquor or preparation, and in the second less of the composition; you also add some sea salt to the second liquor. Experience will teach you soon how to produce every possible shade of crimson.

After the various operations mentioned in the two preceding chapters, there will be in the bottom of the finishing liquor a considerable brown sediment, which is thrown out as useless. This I ordered to be brought to me for examination, and found that the sediment, which remained after scarlet, contained a precipitated calx of tin.

I have even revived the metal, though I must confess with great trouble, so that there can be no advantage in the repetition of what I have done. The remaining particles of this sediment were the dregs of the cream of tartar united with the gross animal particles of the cochineal, which, as I have before said, is a little insect. These little animal particles I washed in cold water, and, agitating the vessel, gathered with a small sieve what was thrown to the surface by the motion of the water. In this manner I divided the light particles from those which were earthy and metallic. They were dried separately, and afterwards bruised with an equal weight of crystals of tartar; when reduced to an impalpable powder, I had a part

of it boiled with a little alum, and suffered a pattern of white cloth to remain in this boiling solution for three-quarters of an hour, at the expiration of which time it was taken out a very beautiful crimson. From this experiment I am convinced that the common custom of reducing the cochineal to powder, and only sifting it, does not sufficiently extract the whole that may be obtained from this precious drug; and I think it incumbent on me, in this place, to mention this experiment for the advantage of those dyers who will be tractable enough to avail themselves of the discovery.

For example, I take an ounce of cochineal, pulverised and sifted as usual. I add to this a quarter of its weight of cream of tartar, very white, very clear, and very dry. These being ground on a painter's marble to an impalpable powder, I use it both in the preparation and in the dye, omitting in the preparation the small proportion of the crystals of tartar which was added to the cochineal. What I put to the dye, though mixed with a quarter of the same salt, so far from injuring the colour makes it evidently more fixed.

CHAPTER XV

Of Gum Lac Scarlet

The red particles of gum lac is also used for dyeing scarlet, and though the colour may not be quite as bright as that obtained from fine cochineal only, it has the advantage of being more permanent.

The gum lac most esteemed for dyeing is in the form of branches, because most furnished with animal particles. That which is reddest in the inside, and at the outside rather a blackish brown, is the best. It appeared from a particular examination of Mr. Geoffrie's, made some years ago, to be a kind of comb, resembling in some degree that usually produced by bees and other insects. It is sometimes used for dyeing stuffs, pulverised and tied up in a linen bag; but this is a bad method, as some part of the gum resin, being melted by the boiling water, escapes through the linen, and so closely adheres to the cloth when cold that you are obliged to scrape it off with a knife. Others reduce it to powder, boil it in water, and when it has communicated all its colour, let it stand to cool; the resinous particles fall to the bottom. The coloured water is then evaporated in the air, where it frequently becomes putrid. When it has acquired the consistence of syrup it is preserved in vessels. Under this form it is difficult to determine the precise quantity, and therefore I endeavoured to find a method of separating the colour from the gum resin, without the necessity of evaporating so large a quantity of water.

I shall not mention the variety of experiments which I made with weak lime-water, with a decoction of the heart of *agaric*, and with a decoction of the root of *birth-wort*, recommended in an ancient dispensatory ; because, though the water left a part of the colour which it had imbibed on the filtering paper, it was nevertheless too much coloured, and therefore it was necessary to evaporate in order to procure all the colour. To avoid this evaporation I had recourse to mucilaginous roots, which of themselves yield no colour, but whose mucilage retains the colouring particles in such a manner as to remain with it on the filter.

I have hitherto succeeded best with the Comfrey root. I use it dried and made into a gross powder, half a drachm to a quart of water, letting it boil for a quarter of an hour ; I then strain it through a linen cloth, and pour it quite hot on the gum lac, pulverised and sifted through a hair sieve. It immediately acquires a fine crimson colour. I put the vessel to digest in a moderate heat for twelve hours, observing to stir the gum which remains at the bottom seven or eight times. I afterwards decant the water impregnated with this colour into a vessel large enough to contain four times the quantity, which I fill with cold water. I then add a very small quantity of a strong solution of Roman alum. The coloured mucilage precipitates ; but if the water still remains coloured, I add some drops of the solution of alum to complete the precipitation, proceeding in this manner till the water becomes colourless. When the crimson mucilage is entirely sunk to the bottom, I draw off the clear water with a syphon ; the remainder I filter, and when perfectly drained cause it to be dried in the sun.

If the first mucilaginous water does not sufficiently extract the colour from the gum lac, so as to leave the gum a pale straw colour, I add some more, boiling hot, repeating everything that

I had done in the first extraction. In this manner I separate all the colour that it is capable of furnishing; but as I had it dried and then pulverised, I knew the whole that may be obtained from this gum, and am also better enabled to judge of my quantities in dyeing than those who are satisfied with the extract procured by evaporation, as that which is most compact will contain most colour.

The best chosen lac, detached from its branches, yield little more than a fifth part of its weight in colour. Hence, considering the price which it bears at present, the advantage of substituting it in the place of cochineal is not so great.

To dye scarlet with the gum lac colour, extracted according to my method, and reduced to powder, requires a peculiar precaution in the diluting, for by putting it into the water when ready to boil, as you do the cochineal, you lose three-quarters of an hour before it entirely dissolves. To be more expeditious, I put the quantity of this dry powder, designed for use, in an earthen, or block-tin vessel; I then pour on it some hot water, and when well moistened, add the requisite quantity of the scarlet composition, stirring the mixture with a glass pestle. This powder, which was before a dark dirty purple, acquires in the solution a fire-colour red, extremely bright. I pour the solution into the liquor to which I had previously dissolved crystals of tartar, and as soon as the liquor begins to boil I dip the cloth, turning and returning it according to the usual method. The remainder of the operation is performed in the same manner as with cochineal. I fancied only that the extract of the gum lac, prepared according to my method, furnished about a ninth part more of colour than the cochineal; at least more than the cochineal which I used in the comparison.

If you substitute a fixed alkaline salt, or lime-water, for crystals of tartar, the bright red of the gum lac will be changed

to the colour of the lees of wine. Hence this colour does not so easily crimson as that of the cochineal.

If instead of these alterants you substitute sal-ammoniac only, you will have cinnamon colours, or light maroon, according as you add more or less of this salt.

I have besides made twenty other experiments with this drug, which I shall not mention, as they produced nothing but such common colours as may be more easily obtained from cheaper ingredients; as I meant only to improve the red colour of the lac, I have been the more explicit in the method of extracting its colouring particles, because the greater the variety of ingredients for dyeing scarlet, the less will be its price. In short, all these experiments respecting the cochineal, lac, and other drugs, apparently of such little use to the dyers, are of some consequence to the philosopher in his inquiry into the causes of the change of colours. From what I have already said it is evident that this subject is inexhaustible. [*The colouring particles of the gum lac may be extracted by water only, without any other addition. The water should be rather more than warm, and the pulverised lac put into a woollen bag, and then trod in the copper. The intelligent dyer will know how to improve upon this.*]

CHAPTER XVI

Of the Coccus polonicus, a Colouring Insect

The *Coccos polonicus* is a little round insect, rather smaller than a grain of coriander seed; it adheres to the root of the *Polygonum cocciferum incanum flore majore perenni* of Ray, and which Mr. Tournefort has called *Alchimilla gramineo folio majore flore.* According to Mr. Breyn it is very abundant in the palatinate of Kiovia, near the Ukraine, near the cities of Ludnow, Piarka, Stobdyfzcze, and in other desert or sandy places in the Ukraine of Podolia, Volhinia, the grand Duchy of Lithuania, and even in Prussia, towards Thorn. Those who gather it know that it is ripe and full of purple juice immediately after the summer solstice. They have a hollow spade with a short handle. With one hand they take hold of the plant, and with this tool in the other hand they raise it out of the ground; they then detach this species of little berries or round insects, and replace the plant in the same hole, that it may not be destroyed; this is done with admirable quickness and dexterity. Having separated the coccus from the earth by means of a riddle for that purpose, they are careful to prevent them from turning into worms by sprinkling them with vinegar, and sometimes also with the coldest water; they then put them in a warm place, or expose them to the sun in order to dry and kill them, but with precautions, as by drying them too precipitately they would be spoilt and

lose their fine colour. They sometimes separate these little insects from their vesicles by pressing them gently with the fingers; they then form them into little round balls. The dyers purchase it at a much dearer rate when made into balls than when in grain. Bernard de Bernith, from whose dissertation I have transcribed the above, adds that the Grand Marshal Konitspolki, and some other Polonian lords who had possessions in the Ukraine, farmed out the harvest of the coccus to the Jews; that the Turks and Armenians, who bought this drug of the Jews, used it for dyeing wool, silk, the tails and mains of their horses; that with it the Turkish women dyed the tops of their fingers a very beautiful carnation colour, and also that the Dutch formerly bought it very dear, and used it with an equal quantity of cochineal; that with the colour of this insect and chalk may be made a painter's lac, equal to that of Florence, and that with it was prepared a beautiful *rouge* for the toilettes of the French and Spanish ladies.

Whether these various properties be exaggerated, or whether the coccus exported from Dantzic was spoiled, I never could, though used in the same manner as the cochineal or kermes, procure any other than lilac, flesh colour, or crimsons more or less bright; nor could I with all my endeavours make it produce a scarlet; besides I found it much more expensive than the cochineal, as it did not yield a fifth part of the colour. This is the reason, probably, that the commerce of this drug is so much fallen, and that the name of the coccus is scarce known in most of the European cities remarkable for having good dyers.

CHAPTER XVII

Of Madder Red

The madder root is the only part of this plant used in dyeing, and is the most permanent of all reds if applied after the wool or stuff has been well scoured, and afterwards prepared with the salts, with which it should boil during three-quarters of an hour; otherwise this red, so tenacious, after the preparation of the subject, will bear trials no better than the red of other ingredients of the false dye. Hence it is evident not only that the pores of the fibres of the wool should be well scoured from the oily perspiration of the animal, which may remain even after the common scouring with water and urine; but that it is likewise necessary that the same pores be internally coated with what I call hard salts, because they are neither calcined by the air nor dissolved by rain or by the moisture of the air in rainy weather. These are: crude white tartar, the red and the crystals of tartar, of which it is usual to put about one-quarter in the *bouillon* or preparation, with two-thirds or three-quarters of Roman alum.

The finest root is generally imported from Zealand, where this plant is cultivated in the islands of Tergoes, Zirzee, Sommerdyck, and Thoolen. That which comes from the first of these islands is most esteemed; the soil being clayey, fat, and somewhat saline. The lands generally preferred for this culture are fresh lands, that have never been ploughed. The Zealanders are obliged for the culture of this plant, and for the great

advantage resulting from the commerce of this root, to the refugees of Flanders.

Madder is distinguished in trade and amongst dyers by the different appellations of grape madder, bunch madder, etc. It is nevertheless the same root; the only difference is that the *grape* is the heart of the root, and the other consists of, besides the heart, the bark and small fibres proceeding from the principal root. The preparation of them both require the same process, which I shall not now relate, as it would be only extending this work to no purpose. It consists in picking out the finest roots for the first sort, in drying them with certain precautions, in separating the bark at the mill, and in preserving the inside of the root moist in casks, where it should remain two or three years, when it will be better for dyeing than if newly ground. If madder be not kept close in this manner it will spoil, and in a great measure lose its vivacity. It is at first yellow, but becomes red and darker as it grows old. Madder should be chosen of a fine saffron colour, in very hard lumps, and of a very strong smell, though not disagreeable. It is also cultivated in the suburbs of Lisle in Flanders, and in many other parts of the kingdom where it is known to grow wild.

The madder used in the Levant and in the Indies for dyeing cottons is in some respects different from that used in Europe. On the coast of Coromandel it is called *Chat.* This plant grows wild in the woods on the coast of Malabar. That which is cultivated is imported from Vaour and Tuccorin, but the most esteemed is the Persian Chat, called *Dumas.*

They also gather on the coast of Coromandel the root of another plant, called *Raye de chaye,* or colour-root, supposed to be a species of madder root, but which is a species of *Galium flore albo,* as we are informed by the *Memoirs* transmitted from India in 1748. This is a long slender root, and gives cotton,

after it has received the necessary preparation, a tolerable fine red colour.

At Kurder, in the neighbourhood of Smyrna, and in the country of Ak-bissar and Yordas, they cultivate another species of madder, called in that country *Chive-boya, Ckme Hazala.* It is, according to some experiments, the best of all madders for dyeing red, and is therefore more esteemed in the Levant than the fine Zealand madder carried thither by the Dutch. This madder, so greatly esteemed, is called by the modern Greeks, Lizari, and by the Arabs, Fonoy. [*These madders, because dried in the air, and not in stoves, give a much better colour than the finest Zealand grape madder. The madder of Languedoc, and even that of Poitou, when dried without fire, succeeds as well as the Lizari.*]

There is likewise another species of madder brought from Canada, and there called *Tyssa-Voyana* : the root is extremely slender, and produces nearly the same effect as the European madder.

The preparation for madder red is pretty much the same as for the red of kermes; it is always made with alum and tartar. With regard to the proportions, dyers are not perfectly agreed; for my part I put five ounces of alum and one ounce of red tartar to every pound of worsted; I also add about a twelfth part of sour water, and in his liquor I let the wool boil for two full hours. If worsted, I keep it well moistened for seven or eight days with this solution; but if cloth, I finish in four days. I prepare for dyeing this wool a fresh liquor, and when the water is so hot as to bear your hand in it, I throw in, for every pound of wool, half a pound of the finest madder, carefully stirring and mixing it well in the copper before I put in the wool, which I keep in it for an hour, without letting it boil, as that would tarnish the colour. Nevertheless, for the dyer's better security it may boil for three or four minutes

at the conclusion of the operation. [*The more madder is boiled, the worse the colour it yields.*]

For shades of madder you proceed as I have already directed for other colours; but these shades are seldom required; a gradation of these not being necessary except for mixed colours. There are, however, a very considerable number of grain colours which must have a madder ground.

If you have several pieces of cloth to dye at the same time, you proceed in the same manner, only increasing the quantity of the ingredients in proportion to my directions; remembering, constantly, that in small operations there should be somewhat more than a proportionable quantity of the ingredients, not only with respect to the red of madder but to all other colours.

These reds are never so beautiful as the red of kermes, and much inferior to those of the lac and cochineal; but they cost less, and are consequently used for common stuffs, the price of which is too low to bear the expense of a dearer colour. The greatest part of the reds worn by the infantry and cavalry are generally dyed with madder, and crimsoned with archil or Brazil wood (drugs of the false dye), but which make them much finer and improves the nap; whereas this advantage could not be procured by means of the cochineal without greatly increasing the price of the stuff.

I have already observed that madder applied to stuffs before they have been prepared in a solution of alum and tartar, will colour them, it is true, but then the colour will be uneven and not permanent, therefore it is the salts which fix the colour. This is common to all colours; consequently red or yellow is not to be obtained without this preparation. The question is whether, by simply extracting the oily perspiration of the sheep, the pores are prepared to receive more immediately the

colouring particles; or rather, whether a part of these salts, especially of the two which cannot be dissolved even by warm water, remains in them in order to attach and secure the colouring atoms, the pores being opened or dilated for their reception by the heat of the water, and afterwards, in order to retain them, contracted by the cold. For the conviction of those prejudiced in favour of the first opinion, let them substitute in the place of alum and tartar, any alkaline salts, such as potash, or lixivium of oak ashes, in a proper quantity so as not to dissolve the wool; and after this preparation the stuffs, being dipped in the madder vat, will take the colour; but then this colour is so entirely unfixed that boiling water only will carry off at least three-fourths of the dye. Now it is impossible to say that fixed alkaline salt is incapable of cleansing the pores of the wool of its animal fat, since lixivial salts are used with success in several cases, where it is necessary to extract that fat from stuffs, of whatsoever kind they be, which water alone will not wash off. It is well known that the extraneous fat and alkaline salts produce a kind of soap, which is afterwards easily washed out with water.

Take a bit of cloth dyed in the red of madder, according to the common method; letting it boil for some time in a solution of a small quantity of fixed alkali, you will in this manner destroy the colour; for the fixed alkali uniting with the minute atoms of the crystals of tartar, by which the pores of the fibres of the wool are lined, produces a soluble tartar which it is well known easily dissolves in water; consequently the pores being opened by the boiling water of the experiment, the colouring atoms are thereby extracted, together with the saline atoms by which they were attached. This stuff being washed in water, the remaining red colour is therein diluted and becomes dirty fawn colour. If instead of alkaline salt you use soap, which is an alkaline salt combined with oil, and for some minutes

boil in it another pattern, which had been also dyed a madder red, this red becomes more beautiful, because the alkali, which in the soap is enveloped with the oil, cannot possibly attack the vegetable acid salt; the boiling only carries off the loose colouring particles, and their number being diminished, what remains will appear less loaded, or lighter.

I say further, as an additional proof of the existence of the salts in the pores of the wool of a stuff boiled in the preparation, before it was dyed with madder, that with this root, by putting in more or less tartar, you procure an infinite variety not only of shades but even of colours, for by diminishing the quantity of alum and agumenting that of the tartar, you produce a cinnamon colour; but if you put nothing into the preparation but tartar, the red is destroyed, and you obtain only a deep cinnamon or fawn colour, but nevertheless of the good dye; because the crude tartar, being an acid salt, dissolves the red particles in such a manner that there remains but a very small quantity with the woody fibres of the root, which, like all common roots, yields only a fawn colour, more or less deep in proportion to the quantity employed. I have already demonstrated that the acid most enlivening to reds will also destroy them, if the quantity be too great, by dividing them into particles of such extreme tenuity that they are imperceptible.

If in the alum preparation for stuffs to be dyed in madder, you use instead of tartar, which is a hard salt, a salt easily soluble, as for example saltpetre, the greatest part of the red becomes useless; it disappears, and you have only a cinnamon colour, very bright indeed, but not sufficiently solid to stand the test, because the two salts used in the preparation are not so firm as the tartar.

The volatile urinous alkalies which develop the red particles from certain plants, such as perilla, archil, and mosses, or lichens,

which, *à priori,* could not have been suspected, develop also the red of the madder root; but they at the same time communicate their volatility to such a degree, then when I used this madder, prepared in the same manner as the archil, with fermented urine and quicklime, I could procure only a nut-brown, either light or dark, but nevertheless durable, because the small quantity of volatile alkali which moistened the madder evaporated in the boiling.

When you apply a pure red, such as the red of cochineal, to a cloth previously dyed blue, and afterwards prepared by a solution of alum and tartar, in order to receive and retain the red, you produce either a purple or violet colour, in proportion to your quantity either of the blue or of the pure red. But the madder has a different effect, because not pure like the red of cochineal, and besides, as I have already observed, it is spoiled by the fawn tinge of the woody fibres of the root. Hence this red, tarnished by the colour of the root, produces with the blue a maroon, more or less dark, according to the intensity of the blue first applied. To give this maroon colour a purple cast, and to confirm it *in grain,* you must necessarily use a little cochineal.

To avoid the colour of the root, the best madder dyers are very careful not to make use of the dye too hot, and to take out their stuff a minute or two after it begins to boil; for if it boils more, the madder is considerably tarnished; the heat of the water being then sufficient to detach the fawn colour particles, so that they are applied with those of the red. This evil may be avoided if, while the madder root is fresh, you can contrive, without much difficulty, to separate from the rest of the root the red circle under the brown skin, by which the pith of the inside is encompassed. But as this process enhances the price of the ingredient, as it requires patience, and after all is never equal to the cochineal, it is therefore hardly worth while to

attempt it in the great. It may however be useful in dyeing cottons, the price of which will bear the expense of this preparation.

Madder being the cheapest of all substances employed for the good dye, it is useful for mixing with others, and thereby diminishing the expense. Half-scarlet, otherwise half-grain, is produced with madder and kermes, and the common half-scarlets and half-crimsons with madder and cochineal.

To make half-grain scarlet you proceed with the preparation and with the rest of the operation as if for the scarlet of kermes in grain, only that in the second decoction you put but half the quantity of the kermes, and the other half of the best madder.

For half fire-coloured scarlet, or scarlet of Gobelins, the composition and preparation are made as usual. To this you put the pure cochineal only; but in the reddening or finish, you put half cochineal and half madder. In this case you may also use cochineal sylvestre, for having made the preparation with common cochineal, if you dye a quantity of wool as for common scarlet, you must put in the reddening two pounds of cochineal; but it would be sufficient to put half a pound of common cochineal, a pound and a half of cochineal *Campassianne*, or *Sylvestre*, and a pound of madder.

To dye wool and stuffs as even as possible, it is absolutely necessary that each of the cochineals be well ground and sifted as well as the madder, with which they should be perfectly incorporated before they are thrown into the decoction. This should be observed with regard to all colours requiring a mixture of several ingredients. The half-scarlet is finished as the common scarlet, and saddened in the same manner, either with boiling water or alum.

Half-crimson is also produced in the same manner as common crimson, adding only half madder and half cochineal.

Cochineal sylvestre may also be used, observing only to retrench half of the common cochineal, supplying its place with three times the quantity of sylvestre ; but if you increase the quantity of the sylvestre, and at the same time diminish the other, the colour will not be so fine.

If you require inferior shades of all these colours, and that you are obliged to match them to patterns, the proportion of madder and cochineal may be augmented or diminished. Hence it is impossible to give any fixed rules concerning this particular ; but from what has been already said, it will not be difficult to discover the best method of succeeding.

I shall finish this chapter with an experiment, from which I have obtained a tolerable purple without the help of cochineal, and also without having previously given the cloth a blue dye I boiled a bit of cloth, weighing about half an ounce, with six grains of Roman alum and six grains of crystals of tartar. At the expiration of half an hour I took it out, squeezed it, let it cool, and then added to the decoction twenty-four grains of grape, or best madder. When it had yielded its colour to this water, yet impregnated with salts, I dropped into it twenty drops of the solution of bismuth, made with an equal quantity of water and spirit of nitre; into this liquor I replunged the cloth, which in half an hour I took out, squeezed, and washed. It appeared to be sufficiently complete; nevertheless, to ascertain the difference which might be produced by an augmentation of the dye, I plunged it into the same decoction, and letting it boil for a quarter of an hour longer, obtained a purple tolerably bright. When tried by the proof of alum it became brighter and more beautiful; and when tried with soap it remains a much finer red than the common madder red.

By keeping the cloth for several days moist in its preparation of alum and tartar, and then dyeing it in a fresh decoction

of madder without salts, according to the usual method, until it had imbibed a bright cinnamon colour, and having afterwards added to the liquor the same solution of bismuth, I have obtained only a maroon colour. This shows the necessity of being accurate in prescribing rules for dyeing, and that for want of this accuracy the books published on this art have been hitherto useless.

In this second experiment the cloth had imbibed too much of the salts; and in the decoction for dyeing there was none. The want of the alum prevented the purple from appearing; because the white earth of this salt was wanting to precipitate with the dissolved particles of the bismuth, which, as I have shown in my chapter of kermes, carry with them the blue particles of the smalt constantly existing in the mineral of bismuth, a portion of which probably unites with this semi-metal in the melting. This mutual precipitation is produced in the operation of dyeing by means of the astringency of the woody particles of the madder root.

CHAPTER XVIII

Of Yellow

There are ten species of drugs for dyeing yellow; but we find from experience that of these ten there are only five fit to be used for the good dye. Nevertheless, as yellow is a common colour in nature, there is no reason why several others should not be added to these five. I shall at present, however, speak of these five only, viz. weld, savory, green wood, yellow wood, and fenugrec, because these are of the good dye. The three first plants are very common in the environs of Paris, and in most of the provinces of that kingdom. The *Bois Jaune*, or yellow wood, comes from the Indies, and the fenugrec is common everywhere.

Weld or wold yields the truest yellow, and is generally preferred to all the others. Savory and green wood, being naturally greenish, are the best for the preparation of wool to be dyed green; the two others yield different shades of yellow.

The shades of yellow best known in the art of dyeing are straw colour, pale yellow, lemon colour, and full yellow. The common orange colours are not simple, and therefore I shall not speak of them at present.

For dyeing worsted and stuffs yellow, you make use of the usual preparation, viz. of tartar and alum. You allow four ounces of alum to every pound of wool, or twenty-five pounds to every hundred. With regard to the tartar, one

ounce to every pound is sufficient for yellow, though it requires two for red. The method of boiling is similar to the preceding. For the welding, that is to say for yellowing, when the wool or stuff has boiled you make a fresh liquor, allowing five or six pounds of weld to every pound of stuff; some enclose the weld in a clean woollen bag, to prevent it from mixing in the stuff; and to keep the bag down in the copper they put it on a cross of heavy wood. Others boil it in the liquor till it has communicated all its colour, and till it falls to the bottom; the stuff is then suspended in the net, which falls into the liquor; but others, when it has boiled, take out the weld with a rake, and throw it away. They sometimes mix yellow wood with this weld; and some dyers mix any of the other ingredients before specified according to the shade required. By varying the proportions of the salts for the preparation, the quantity of the colouring ingredient, and the time of boiling, I am convinced that it is possible to produce an infinite variety of shades. I know it from my own experience, and from the experiments which I made with the flower of the *Virga aurea Canadensis*, which would be a useful acquisition in the art of dyeing, should anyone think it worth their while to cultivate this plant, as it throws out many suckers, which are easily transplanted.

For regular shades of light yellows you proceed as for all other regular shades, only that light yellows require a weaker preparation. For example, twelve pounds and a half of alum to a hundred pounds of wool is sufficient. The tartar should also be diminished, because the wool is always wasted a little by the preparation, and that when you require only light shades they may be as easily obtained by a weaker preparation; thus you save also in the expense of the salts. But these light shades do not so well stand the test as the darker shades, which are dyed with the full proportion of tartar. Some dyers suppose that by letting their wool and stuff remain longer in the dye

they remedy this evil, because they imbibe the colour more slowly in proportion to the weakness of the decoction. If you put wool into the dye, differently prepared, it will in the same time imbibe different shades. These weaker preparations are called half preparations or quarter preparations, and require great attention, especially for light shades of wool when dyed in the fleece for the manufacture of cloth and mixed stuffs, because the wool is harder and more difficult to spin, in proportion to the quantity of alum in the preparation. The stuff is consequently less fine. This observation is not, however, of much importance with regard to worsteds for tapestry, neither with respect to stuffs; but it is not much amiss were it only to show that the quantities of the ingredients used in the preparation are not so very exact, but that they may be varied without any risk, whether to give the same shades to wool, prepared in different preparations, or whether to make but one preparation, if more convenient for different shades.

In order to dye with yellow wood, it should be split, or rather shaved with a joiner's plane; by this means it is more divided, consequently yields better, so that a smaller quantity will do. Prepare it as you will, it should always be tied up in a bag, to prevent it from mixing with the wool and from tearing the stuff. The savory and green-wood, when used instead of weld, in order to vary the shade, should be enclosed in the same manner.

The other five ingredients for dyeing yellow I class with those for dyeing the false dye. With regard to the good dye I shall here mention only the root of the dock, the bark of ash, especially the second bark; the leaves of the almond tree, peach, and pear tree; in short, all astringent leaves, barks, and woods. These will produce good yellows, more or less fine, according to the time they have boiled, and in proportion as the alum or tartar predominates in the preparation. A

larger quantity of alum makes it almost as fine as the yellow of weld; if the tartar prevails, the yellow has more of the orange; but if these roots, barks, or leaves, boil too much, the yellow terminates in shades of fawn colour.

Though several dyers are accustomed for the good dye to use turmeric, a root imported from the East Indies, and which produces an orange yellow, it is, however, blamable; because the colour very soon fades, at least if not fixed with marine salt, as practised by some dyers who carefully conceal this art. Those who use it for common scarlet, in order to save cochineal, and to give a lively orange red, are also reprehensible; for, as I have already observed, scarlets dyed in this manner very soon lose their bright orange cast, which darkens by the air. We are, however, obliged in some degree to tolerate the deception, for this flaming colour being so much in vogue, it were impossible to produce it otherwise but by increasing the quantity of composition, the superabundant acid of which considerably injures the cloth.

CHAPTER XIX

Of Brown, or Fawn Colour

The fawn colour, root or nut colour, is the fourth primitive colour in the dyer's class. It is so classed, being introduced into a great number of colours. It requires a very different process from the others, because the wool to be dyed a fawn colour has scarce ever any preparation otherwise than being soaked in warm water in the same manner as for blue.

For dyeing fawn colour you make use of the green shell of the walnut, the root of the walnut tree, the bark of the alder, santal, sumach, roudoul or fovic, and soot.

The green shells of the walnut, collected when the nuts are perfectly ripe, and put into tubs or casks and afterwards filled with water, are in this manner preserved till the year following. The shells are also used before the nuts are ripe; but these should be saved apart, in order to be first used, because as the soft shell which adheres putrefies, it will keep but for two months only.

The santal or saunders is a hard wood imported from the Indies, generally ground into a very fine powder, and preserved in bags; because it is supposed to ferment; by which it is thought to be greatly improved, but I have never observed any difference. This ground wood is generally used with one-third of cariatour wood, by which, in the opinion of those who prepare it for sale, it is much improved. It is, however, nothing like so good as the walnut shells, because if used in too large

a quantity it stiffens considerably, and thereby injures the wool; hence it were best not to use it, either for wool or fine stuffs, except in the lighter shades, where it would not have so bad effect. It is generally mixed with galls, alder bark, and sumach, as by this means only you can obtain its colour when not mixed with the cariatour. It yields but very little with the preparation of alum and tartar, especially if it be not chipped; but notwithstanding these defects it is tolerated in the good dye on account of the solidity of its colour, which is naturally a yellow red-brown. The air makes it deeper, and soap lighter. It loses but little by a trial of alum, and still less by tartar.

Of all the ingredients for dyeing fawn colours the walnut rind is the best. Its shades are finer, its colour solid, and by making the wool flexible, renders it less difficult to work. It is prepared in the following manner:—You fill a cauldron half-full of water, and when it grows warm you add rinds in proportion to the quantity of stuffs to be dyed, and to the colour required. It is then boiled, and when it is boiled for a quarter of an hour, the stuffs, having been previously moistened with warm water, are dipped; they are then turned and well stirred, till they have imbibed the colour desired. If for worsteds, requiring an exact assortment of shades, you put less walnut rinds, and begin with the lightest shades. You put more walnut rinds in proportion as the colour is exhausted, and then dip the darkest shades. With regard to stuffs, you generally begin with the deepest, and as the colour of the dye diminishes, you dip the lightest. They are aired as usual, dried, and dressed.

The root of the walnut tree is, next to the husk, the best dye for fawn colour. It also gives a very great number of shades, nearly resembling those of the husks; hence they may be substituted for each other, but the root requires a different process. You fill your cauldron three-quarters full of river

water, putting in the root, cut small, in proportion to the quantity of wool to be dyed, and to the shade required. When it is very hot you dip the wool or stuff, turning and returning it as before, remembering to air it from time to time; and if stuff, to draw it through the hands in order to shake off the small bits of the root, which might else spot the stuff. To avoid these spots the root should be tied in a bag, in the same manner as the yellow wood. You afterwards dip the lighter stuffs, and so on, till the colour of the root is exhausted. If worsted, you always begin with the lightest, as for other colours; but of all things you must be careful to keep your liquor from boiling at the beginning, as in that case the first piece of stuff would imbibe all the colour.

The method of dyeing with roots is not very easy; for if you are not very attentive to the degree of heat, to turning and returning the stuffs or worsteds, so as to dip them equally, you run a risk of their being either too dark or spotted, for which there is no remedy. In this case the only resource is to dye them maroon, prune, or coffee colour, as I have already observed when speaking of colours and shades resulting from a mixture of fawn colour and black. In order to avoid this evil you must keep the stuffs continually turning on the reel, and dip them only piece by piece, nor let the colour boil till the root has yielded all its colour. The worsteds or stuffs dyed in this manner should be aired, well washed, and dried.

I can say nothing more concerning the bark of alder, than what I have already observed with respect to the root of the walnut tree, only that letting it boil at the beginning is not of so much consequence, because it yields its colour less freely. It is generally used for worsteds and colours darkened with copperas. It nevertheless produced a good effect on wool not intended for colours extremely dark, and perfectly withstands the power of the air and sun.

Sumach is nearly of the same nature, and used in the same manner as the husks: its colour is not so deep, and is rather greenish. It is for dark colours frequently substituted for nutgalls; but a greater quantity is requisite. Its colour is also perfectly solid and permanent. These different substances are sometimes mixed together, and as they are equally good and produce nearly the same effect, there is no great difficulty in obtaining certain shades. We must, nevertheless, be directed by custom in the production of these fawn colours shades, which absolutely depend upon the eye, and which are not difficult to manage.

With regard to the mixing of these ingredients with ground santal, you put four pounds of the latter into the copper, half a pound of nutgalls pounded, twelve pounds of alder bark, and ten pounds of sumach (these quantities will dye twenty-five or twenty-seven ells of cloth). The whole is boiled, and having checked the boiling with a little cold water, you immerse the cloth, turning and restirring it for two hours; it is then taken out, aired, and washed at the river. You afterwards dip some more stuff in the same decoction, if you want a lighter shade; and in this manner you may contrive so long as the liquor retains any colour. The quantities of these ingredients are augmented or diminished in proportion to the depth of the shade required, letting the wool or stuff boil accordingly. I have already observed that there is no other method of obtaining the colour of the santal or saunders.

I have here mentioned the saunders and the method of using it, though perhaps it would have been more seasonable when treating of the false dye, considering that this wood should never be used but for low-priced stuffs. Nevertheless, as it is employed almost in the same manner as the other ingredients for fawn colours, and as there are many provinces where it is tolerated in the good dye, because it withstands

the weather, I thought it might be as well to mention the method of using it in course with the other ingredients. I shall for the same reason describe also the manner of dyeing with soot, though permitted only for the false dye, having less solidity than the others, and because it hardens the wool and gives stuff a very disagreeable smell.

The water and soot is generally put into the copper at the same time, and the whole well boiled. The stuff is then immersed and more or less boiled according to the shade required; it is afterwards taken out and cooled, and those intended for the lighest shade are then put in; they are afterwards well washed and dried. But the best method is to boil the soot in the water for two hours, to let it stand afterwards, and then to empty the liquor into another copper, without mixing the soot.

The wool and stuffs are then dipped in the liquor, and are thereby less hardened than if they had been mixed with the soot; but this does not render the colour more permanent, and indeed it were better never to make use of this ingredient, except for stuffs of little value, especially as it can be supplied by other ingredients which I have mentioned above, and which give a better and more lasting colour, and are besides more softening to the wool. In the dye they frequently employ the green walnut shell, and the root of the walnut tree for their fawn colours. Those two substances are useful both for the greater and lesser dye: there are, however, places where it is difficult to meet with them, and where they are therefore obliged to make use of saunders, and even of soot.

The reasons which I have above given for the solidity of *true* colours may seem to be contradicted by this method of dyeing, in which the colour adheres permanently to fawn colours, without the previous preparation of alum or tartar, consequently without introducing into the pores of the fibres

a salt capable of being hardened by cold and of retaining the colouring atoms. But if we examine the green shell of the walnut, the root of the walnut tree, the bark of the alder, by a chemical analysis, besides their well-known astringent qualities, we shall find, by decomposing them according to art, that they contain a vitriolated tartar, a salt, which is neither calcined by the sun nor dissolved, except by boiling water, and we shall then perceive that these ingredients are of themselves sufficient to produce effects equal to those drugs whose colours cannot be solidly applied without the assistance of a salt capable of retaining the colouring atoms. Soot does not give a colour so permanent, because it contains only a volatile and marine salt easily dissolved. In short, soot being composed only of the lightest and most volatile particles of combustible bodies, used as the pabulum of fire, cannot raise a vitriolated tartar, which does not become volatile by heat, and which besides rarely exists in the wood usually burnt in our chimneys.

CHAPTER XX

Of Black

Black is the dyer's fifth primitive colour. It includes a prodigious quantity of shades, beginning from the lightest grey, or pearl colour, to black. On account of these shades it is ranked among the primitive colours, for the greatest number of browns, of whatsoever shade they be, are finished in the same dye, which would dye white wool a grey, more or less dark. This operation is called browning. I shall speak of this when I come to treat of the shades resulting from a mixture of the primitive colours; but I shall now give the method of dyeing wool a fine black. For this purpose I shall be obliged to speak of a process used in false dyeing. In order to dye stuff a fine black, it should be begun by a great dyer and finished by a dyer of the lesser dye.

Stuffs should be first dyed, when intended for black, a mazarine blue, as deep as possible, called the basis or ground, which should be executed by great dyers, and in the same manner as I have directed in my chapter upon the blue. The stuff should be washed at the river as soon as it comes out of the woad vat, and should be well scoured in the fulling mill. The washing is of great importance, because without it the lime in the liquor spots, and injures the stuff. It is also very necessary to scour it in the fulling mill, else it blackens the linen and the hands, as is frequently the case when it has not been sufficiently scoured.

After this preparation the stuff is finished and blackened, which is performed in the following manner in the lesser dye :—

For a hundredweight of cloth or stuff, which, according to the *Regulations*, should have had a grey-blue ground, you put into a moderate cauldron ten pounds of logwood cut into chips, and ten pounds of Aleppo galls pulverised, the whole enclosed in a bag: these ingredients are boiled in a sufficient quantity of water for twelve hours. A third part of this liquor is emptied into another cauldron, with two pounds of verdigris; the stuff is then entered and turned for two hours without ceasing. It is necessary to observe that this liquor should boil very slowly; or it is still better to keep it very hot without boiling. The stuff is then taken out, and the second third of the liquor thrown into the copper to the first third, with the addition of eight pounds of copperas. The fire under the cauldron is diminished, and the copperas left to dissolve for half an hour, letting the liquor cool, after which the stuff is kept turning an hour; it is then taken out and cooled. The rest of the liquor is then mixed with the two first thirds, carefully squeezing the bag well. To this is added fifteen or twenty pounds of sumach. You give it another boil, and then cool it with a little water; having previously added two pounds more of copperas, you again turn the stuff for two hours; it is then taken out, cooled, and again put into the cauldron, turning it constantly for an hour longer. After this it is carried to the river, well washed and scoured at the fulling mill. When it is thoroughly scoured, and that the water comes out of it clear, you prepare a fresh liquor with as much weld as you think proper; you give it one boil, cool it, and dip the stuff. This last decoction softens and confirms it a very fine black. For the most part, however, they do not take so much pains; but are satisfied, when

the cloth is blue, to dip it in a decoction of nutgalls, and to let it boil for two hours. It is afterwards washed, and some copperas and logwood added to the liquor; after which the stuff is again dipped for two hours, and then washed and scoured.

I have also dyed in the following manner:—For fifteen ells of cloth, previously dyed blue, I had a pound and a half of yellow wood, five pounds of logwood, and ten pounds of sumach put into a cauldron. In this the cloth boiled for three hours, after which it was taken out, and ten pounds of copperas thrown into the copper. When the copperas was dissolved and the liquor cooled, the cloth was put into it for two hours; it was then taken out and cooled, after which it was again immersed for an hour, and then washed and scoured: it was tolerably fine, but not so velvety as the preceding.

It was commanded by the ancient *Regulations* that stuffs should be maddered after they had been blued, and before they were dyed black. Desirous of ascertaining the advantage resulting from this process, I took a bit of cloth which had been dyed blue; this being divided, one half was boiled with alum and tartar, and afterwards maddered. It was then blackened in the same liquor with the other half which had not been maddered conformable to the first of the two methods just described. They were each of them a very beautiful black: it nevertheless appeared that the maddered stuff had a reddish cast: the other black was certainly more beautiful, more velvety, and much finer. There is indeed less danger of the maddered stuffs soiling the hands and linen, because the alum and tartar of the preparation had carried off all the loose particles. This advantage is not, however, sufficient to make amends for the inconvenience of maddering, as the stuff is always in some degree injured by the alum and tartar, and as the madder gives it a reddish cast disagreeable to the

eye, and besides, this operation raises the price of the dye to no purpose.

Some dyers, to avoid these inconveniences in part, madder their cloth without having previously boiled it in alum and tartar. But I have already shown that madder used in this manner has no permanency; hence I cannot perceive the advantage resulting from so bad a practice.

Black is sometimes dyed without having given it the blue ground; and this method of dyeing was permitted for light or thin stuffs of inferior value, consequently not considerable enough to bear the expense of a deep blue previous to their being dyed black. It was, however, ordered at the same time to give these stuffs a ground of the green walnut shell, or of the root of the walnut tree, to avoid the necessity of blackening them with too great a quantity of copperas. This process entirely regards the false dye; nevertheless, as it was also allowed to other dyers, this seems the proper time to mention it, especially as I am speaking of colours appertaining to both.

This process is attended with no manner of difficulty. The cloth, as we have already seen in the chapter upon fawn colour, is prepared with the green walnut shell, and afterwards blackened in the manner I have already described, or as near it as possible. For with black, as with scarlet, most dyers suppose that they are possessed of a secret for dyeing a much finer black than any of their fraternity; this, however, consists in augmenting or diminishing the quantities of the same ingredients, or in substituting others which produce the same effect. I have myself tried several methods, and fancy that what is strictly meant by succeeding to perfection, depends rather on the manner of working, handling, and airing the stuff properly, than upon the exact quantity of the ingredients. For this reason I have been more particular than may be thought

necessary in my description of what appeared to me to be the best method.

It may not in this place be improper to explain the reason of the necessity of giving stuffs a blue, or at least a root colour ground, previous to their being dyed black; and why the dyeing white black is expressly prohibited, because in that case it is necessary to use a much greater quantity of nutgalls; this would indeed be no great evil, as nutgalls of themselves do not injure the wool; but in order to *overcome this gall*, according to the workman's phrase, that is, to blacken it, or properly speaking, rather to form an ink on the stuff, it requires a greater quantity of copperas, which not only hardens the stuff but, from the acidity impressed on the fibres of the wool by this fault, makes it brittle: on the contrary, when the stuff has had a ground, that is to say, a strong layer of some deep colour, there is much less occasion for either.

Blue is preferable to any other colour; first, because it is the nearest to black, which is in fact only a deep blue; and secondly, as there is no occasion for any other preparation than previously boiling the wool, the stuff is in no respect injured. For the same reason, viz. the preservation of the wool, the root colour is substituted for inferior stuffs, instead of the blue, which would enhance the price; it is therefore necessary that this root colour ground should be as deep as possible; because the darker it is there is occasion for less copperas to complete the black.

It also frequently happens that when stuffs of any colour are badly dyed, or spotted, they are dipped in black: it is, however, advisable to dip them first in blue, unless the colour be very dark, in which case they would take a very fine black; but this is the last resource. These stuffs are not commonly dyed black, if it be possible to make them any other colour; because, having been prepared with alum and tartar for the

first colour, the copperas requisite for the black would considerably injure and greatly diminish their quality.

The shades of black are greys, from the darkest to the lightest. They are of great use in the art of dyeing, as well for their own colours simply as when applied to other colours, which is called darkening; but I shall speak of these more particularly when treating of their mixture with the primitive colours. At present I shall confine myself to greys only, and consider them as shades proceeding from black, relating the two methods of producing them.

The first and most general method is to boil some pounded nutgalls with a proper quantity of water for two hours, at the same time dissolving some copperas in a little water separately. Having prepared a cauldron of liquor sufficient for the quantity of wool or stuff to be dyed, you add to it, whilst the water is too hot for your hand, a little of the decoction of the nutgalls with the solution of copperas. The stuff intended for the lightest grey is then dipped. When sufficiently coloured according to your desire, you add some fresh decoction of nutgalls with some of the infusion of the copperas, and then dip the next shade. In this manner you proceed to the darkest shade, constantly adding these liquors, from the tawny grey even to black; but it is much better to give the tawny grey and the extreme dark shades a blue ground, more or less as you like, for the reason above mentioned.

The second method of producing grey is in my opinion preferable, because the juice of the galls is better incorporated with the wool, and that you are thereby sure of using no more copperas than is absolutely necessary. It even appears from the experiments I have made that the greys are more beautiful and the wool brighter. It also appears to be equally solid; for they are both of them equally proof against the air and sun. What determined me therefore in favour of the second method

is, that besides its being much less prejudicial to the quality of the wool, it is attended with no more difficulty than the first.

You boil a sufficient quantity of nutgalls, well pounded and enclosed in a clean linen bag; you afterwards put the wool or stuff into this liquor, letting it boil for an hour, moving and stirring it about, after which it is taken out. You then add to the same liquor a little copperas dissolved in a part of the solution, and then dip the woollens intended for the lightest shade. You again add a little of the copperas solution, continuing in this manner as in the first operation, till you come to the darkest shades. In either process, if not restrained by patterns, you may catch the precise shades, beginning with the dark and finishing with the light, in proportion as the liquor becomes exhausted of its ingredients; keeping the pieces of stuff or wool immersed for a longer or shorter time, till the stuff takes the colour desired.

It is as impossible to determine the quantity of water necessary for these operations, as it is to specify the quantity of the ingredients, or the time for letting the wool remain in the liquor. The eye must judge of these things. If the liquor be strongly impregnated with colour the wool will imbibe the shade in a short time, but on the contrary it must remain longer if the liquor be exhausted. When the wool is not dark enough it is dipped a second time, a third, or even more, till it is of a sufficient colour; the only necessary attention is to prevent the water from boiling. If it be by chance too deep, the only remedy is to dip the stuff in a fresh warm liquor, adding to it a little of the decoction of nutgalls. This liquor carries off a part of the precipitated iron of the copperas; consequently the wool or stuff becomes lighter.

But the best way is to take it out of the liquor from time to time, not leaving it in long enough to imbibe more of the colour than required. It may also be dipped in a solution of

soap or alum; but these correctives destroy a great part of the colour, so that it is often necessary to darken it again; by this means the wool, which suffers greatly by the reiterated action of these ingredients, is injured. All greys, however dyed, should be well washed in a large stream, and the darkest even scoured with soap.

These dingy shades, from the lightest to the darkest, are produced by the same operation from which common ink is obtained. The green vitriol contains iron; were it blue, it would contain copper. Pour a solution of this green copperas into a glass, holding it in the light, and dropping into it some of the decoction of nutgalls. The first drops that fall into this limpid solution of ferruginous salt produces a reddish colour, the next turns it bluish, then a dusky violet colour, and at last it becomes a dark blue, almost black, which is called ink. To this ink add a quantity of pure water; let the vessel rest for several days, and the liquor by degrees becomes clearer and clearer, till it is almost as limpid as common water, and at the bottom of the vessel you will perceive a black powder. Having dried this powder, put it into a crucible; calcine this, and put to it a little suet or any other fat, you will obtain a black powder which may be attracted by the loadstone. This, therefore, is iron; this is the metal which blackens the ink, and this, when percipitated by the nutgalls, lodges in the pores of the fibres of the wool dilated by the heat of the liquor, and contracted when the stuff is exposed to the air. Besides the styptic quality of the nutgalls, by which they have eminently the property of precipitating the iron of the copperas, and producing ink, they also contain a portion of gum, as may be ascertained by evaporating the filtered decoction. This gum being introduced into the pores with the ferruginous atoms serves to retain them; but this gum being easily soluble, it has not the tenacity procured from a salt more difficult of

solution; therefore these dark colours have not the solidity of other solid colours prepared in a boiling solution of alum and tartar, and therefore plain greys have not been submitted to the usual trial.

Thus have I, to the best of my knowledge, given the best methods of producing what the dyers call primitive colours; or at least those which they suppose most deserving of that appellation, as from their mixture and combinations all other colours are derived. I shall now begin with the simple combination of two colours, in the same order in which I have described them singly. When I have given the colours resulting from their first degree of combination, I shall join them by threes; continuing in the same manner till I have exhibited every colour existing in nature and imitated by art.

CHAPTER XXI

Of the Colours Obtained from a Mixture of Blue and Red

When speaking of red I observed that there were four different species *in grain*. We shall now see what these reds produce when applied to a stuff previously dyed blue. A blue stuff boiled in alum and tartar, according to my directions in the article concerning red, and afterwards dyed with the kermes, the result will be the king's colour, prince's colour, violet, purple, and several such colours. But for these colours they seldom make use of kermes on account of its high price and the quantity required, and because the same colour produced by cochineal and madder are both finer and obtained with less difficulty. Besides, I have already remarked that kermes is not much in use, though it produces several compound colours with good effect, as will be more particularly shown in the sequel. When kermes is used in order to apply red to blue, it is of no consequence whether the blue ground be given before or after the stuff has been dyed red, the red of kermes being too permanent to be changed either by the lime of the woad vat, at least if not overcharged, or by the potash of the indigo vat. If, therefore, the woad vat be not too old, you may begin with either of the two colours as you like, or as you shall think most suitable to the shade required. It is easy to conceive, though I have mentioned but a very small number of colours, that from these two principals a very large quantity of shades

may be obtained, according as the one or the other predominates.

You never mix blue with fire colour scarlet, or with the scarlet of Gobelins, in any of their shades. In order to discover the cause of this, I dipped a bit of scarlet cloth in the blue vat, and dyed a second bit according to the scarlet method, having previously dipped it in the blue vat. They each of them succeeded very ill, and produced a dusky marbled violet colour, as if the two colours were not well united, and had been applied separately to different parts of the wool. This was doubtless occasioned by the acids in the composition of the scarlet. But I shall not now examine this operation physically, as it would produce a tedious dissertation ; the fact is sufficient. It proves the impossibility of procuring a fine colour from a mixture of blue with scarlet, unless the scarlet be dipped in a solution of alum, by which the acid of the composition would be destroyed ; but then it would be crimson, a colour very different from scarlet; the process of which I have given in a particular chapter.

A mixture of blue and crimson produces columbine, purple, amaranth, pansy, and violet colour. These colours also produce a very great number of shades, which vary according as the colours from whence they are derived are more or less dark. I have been so minute in my directions for the management of the primitive colours, that it is impossible for the least difficulty or embarrassment to occur in the execution of the compound colours. The stuff and worsted being of one colour, it is afterwards dyed another, precisely in the same manner as if it had been quite white. You must only observe, in the present case, to dye the stuff blue before you dip it crimson, because the alkali of either of the blue vats considerably tarnish the brightness of the cochineal. Take notice, that in producing violet, purple, and such like shades, to observe what I have already said concerning crimson, because these colours have

no vivacity or brightness if not managed with all the precautions necessary towards the production of a fine crimson.

Blue and the red of madder produce king's purple, etc., but much inferior to that obtained from the kermes, because the red of this root is always tarnished by the colour of its woody fibres. The minime, tan colour, amaranth, and the dry rose colour are always less lively than if obtained from the kermes. It is nevertheless sometimes mixed with madder, as I have already said, in order to produre scarlet half-grain; and the colours produced from it are much finer than those obtained from the madder only applied to a blue stuff. Madder mixed with cochineal, as for half-crimson, gives a vast number of shades, which bear some affinity to those already mentioned, but which it were impossible to specify particularly. Some of them are as fine as those produced by more expensive ingredients. As it is incumbent on dyers to attend to their own advantage, they will not make use of the dearest when it is possible to produce the same effect with common ingredients. It is difficult to give particular instructions upon a practice that must be acquired from experience only. Old madder and cochineal liquors are frequently used when the colour is not entirely exhausted; they produce a very good colour, and save a considerable expense. With regard to this, however, I can say nothing positive, as its effects depend on the quantity of colour remaining in the liquor, and on the degree of shade required.

CHAPTER XXII

Of the Mixture of Blue and Yellow

It is impossible to obtain more than one colour from a mixture of blue and yellow, which is green; but this colour comprehends an infinite variety of shades, the principal of which are yellow green, pale green, bright green, grass green, laurel green, olive green, sea green, parrot green, and cabbage green. To these may be added duck's-wing green, and sea green without blue. These shades, with their intermediate ones, are produced in the same manner and with the same ease. You take stuff or wool, either a dark or light blue, and having boiled it in alum and tartar, as you would white stuff for common yellow; you afterwards dye it with weld, savory, or greening wood. These several substances are equally good with regard to their solidity; but as they give different yellows, the green resulting from their mixtures are also different. Weld and savory give the finest greens.

For yellow green shades the stuff should be a fine light blue, boiled with the common quantities of alum and tartar, in order to receive the yellow; as without these salts the colour would not be permanent. For cabbage or parrot green, the blue should be very deep; but as it ought to have but a tinge of yellow, the stuff will require but half the boiling. Even a quarter of the salts of a common preparation is sometimes sufficient, as I have already explained. The workmen, for these kind of colours, seldom weigh the salts, judging by the

eye the quantity sufficient for the shade required. Constant practice will in some degree make them tolerably exact, but it were to be wished that they would not trust to the eye in this particular. I know from experience that these blue-green shades are produced as well by giving the stuff the usual preparation. The yellow afterwards applied is much more solid; but then there is much less weld or other colouring substance required, neither should the stuff be left so long in the liquor. Nevertheless there are two reasons to the contrary: the first, and most interesting to dyers is, that they fancy they consume a greater quantity of ingredients than necessary; and the second, that the smaller the quantity of alum the more you preserve the softness and quality of the wool; and also that the first blue dye is less impaired, as the alum always deadens the blue obtained from the woad. Hence I am of opinion that in this particular the dyer should be at liberty to regulate the strength of his preparation by the depth of the colour required.

I have said that in order to dye green the wool should be previously dyed blue; because it is my opinion that when the colours are thus applied the green is more durable, and that the colour would not be so fine were it otherwise. I was convinced of this in dyeing the greens of which I have been speaking. I found that they all stood the weather. Those which were first dyed blue were the least affected; but with regard to the trial liquors there was evidently much less difference.

Nevertheless, whenever it is necessary, the dyer should be allowed to dye their stuffs yellow first; but then these soil the linen much more than the others; because when the blue is first given, the loose particles are washed off by the alum preparation. The best remedy for this defect is to have the green well scoured when taken out of the vat, by which means

it will be rendered like the blue mentioned in the tenth chapter.

King's blue cloth dipped green with the flower of the *Virga aurea Canadensis* becomes a very fine green provided the stuff is boiled in a solution of three parts alum and one part white tartar. This green is equally permanent as that dyed with weld.

I have also greened blues with the bark of ash tree pulverised; this is perfectly solid, but not fine, and therefore of no use except for particular colours. The leaves of the almond, the peach, and pear tree, etc., as they furnish yellows, may serve for those green shades which it may be difficult to hit immediately with the ingredients hitherto employed for dyeing yellow.

A king's blue stuff, well scoured, and afterwards boiled in a solution of four parts alum and one part tartar, takes a fine dark green of the duck's-wing shade, if it be boiled for two full hours in a vat with a sufficient quantity of the root of *Lapatum folio acuto*, sharp-pointed dock grossly powdered.

This root is also a good acquisition in the art of dyeing, for it will, without any other addition than the preparation, give an infinity of shades, from the palest yellow to a tolerable olive colour; it requires nothing more than to increase or diminish the quantity put into the vat, and to boil it from half an hour to three hours. All these shades withstand the trial of boiling. I would strongly recommend the cultivation of this root in moist places, and the use of it in dyeing, as it is already used in medicine, especially for the poor.

Sea green, a particular colour, and much the taste of the people of the Levant, may be made perfectly solid by giving the stuff a blue ground; but this blue shade should be very faint, scarcely exceeding a bluish white, which it is difficult to dye equal and uniform; but when you have obtained this

shade, the *Virga aurea* above mentioned is better for giving the yellow tinge than the weld. But this *Virga aurea* is not yet known to the dyers of Languedoc, by whom these kind of colours are chiefly made ; and, besides, the blue shade required being very difficult to obtain, they are sometimes permitted to dye sea greens with verdigris, though this colour is classed amongst the false colours. The Dutch make this colour very well, and more solid than is usual with verdigris. The following is their method of proceeding :—

It requires two cauldrons placed at a little distance from each other. In one of these cauldrons you put for two pieces of cloth, of about forty-five or fifty ells long, eight or ten pounds of white soap shaved, which should be perfectly dissolved. When the vat is ready to boil, the stuff should be immersed, and suffered to boil for a good half-hour. You prepare another liquor in the other cauldron, and when it is quite hot you put into it a clean linen bag containing eight or ten pounds of blue vitriol and ten or twelve pounds of lime, each of them pulverised and well mixed together, for it is necessary that this mixture be as accurate as possible. This bag should be moved about in the hot water, but not boiling, till the vitriol is dissolved. You should then fix on the two forks a winch made as usual, but which should be carefully wrapped round with a clean lined cloth very tight and well sewed. One end of the cloth is fixed on the winch, which is turned swiftly round that the cloth may pass quickly from the soap cauldron into the cauldron with the vitriol; it is then turned more slowly, that the cloth may have time to imbibe the particles of copper which, by means of the lime, were diffused in the liquor, by separating and precipitating them from the blue vitriol in which they were contained. The cloth is left in this liquor, which should never boil till it has taken the sea green shade required. It is then taken out, drained on the winch, and

aired by the lifting. It should then hang till it is perfectly cold before it is washed at the river. If it touches wood before it has been washed it will spot; for this reason the winch is covered, and for the same reason the horse should be also covered before the cloth is folded over it.

CHAPTER XXIII

Of the Mixture of Blue and Fawn Colour

The olive shades resulting from blue and fawn colour are of very little use except in the fabrication of tapestry. There is no difficulty in making them when required; and it is absolutely indifferent whether you begin by dipping your worsted blue or fawn colour; if the latter, you should be careful to rinse your worsted, which should be always observed with regard to blue, and also for such compound colours as are completed in the blue vat. When you would produce these colours, it is equally indifferent which of the fawn colour substances you use; the preference being due to those only which give the shade required with the least difficulty.

CHAPTER XXIV

Of the Mixture of Blue and Black

From this mixture there is no particular shade to be obtained, as the grey only darkens the blue, which may be better effected by giving them the shade required in the blue vat. You may, nevertheless, by a mixture of blues and greys, which are numbered amongst the black shades, as I have observed in Chapter XX., produce tawnies. In this case the blue should not be very deep, and the process is then the same as for black, only that as the colour is not quite so dark you should not put so much copperas ; but, as I have before said, this colour should be considered only as a black shade. Hence it may be truly said that no shade can be obtained from blue and black only, and but very few from blue and fawn colour.

CHAPTER XXV

Of the Mixture of Red and Yellow

Scarlet of kermes and yellow produce aurora, *couleur de souci*, and orange colour. When the wool has been boiled in alum and tartar it may be dyed in one of these colours, and afterwards dipped in the other, or it may be dyed at once by mixing the kermes with weld, savory, etc. But the precise shades are more easily obtained by the first method, as the wool or stuff may be dipped alternately till it has taken exactly the shade required.

From common scarlet, or scarlet of Gobelins, and yellow you procure lobster colour, and the colour of the pomegranate flower; but they are not very permanent. They are dyed in the following manner:—You begin with the scarlet just as I have before directed, that is, by boiling with cream of tartar, cochineal, and the composition; it should then be taken out, cooled, and washed at the river. In order to finish, you must prepare a fresh liquor as for scarlet, only lessening the quantity of the cochineal and substituting a little ground yellow wood. I cannot, however, specify exactly the quantity either of the cochineal or yellow wood, as that depends upon the colour required. If an orange colour, you add a greater quantity of the yellow wood, diminishing the cochineal in proportion.

I have endeavoured to produce this colour by three different methods, and succeeded in them all. The first method I have

just described. The second is to substitute fustic for yellow wood, which is a considerable saving of cochineal, being much more upon the orange than yellow wood; but this ingredient wants solidity, and should never be used but for false colours; so that it is tolerated in Languedoc for dyeing cloth the lobster colour, so much admired in the Levant, only because the colour obtained from it is more beautiful than that produced by the yellow wood.

The third method of procuring the lobster colour, with cochineal only, is by augmenting the quantity of the composition according to the degree of orange required; but this method is attended with very great inconvenience. In the first place, it enhances the price of the colour, as it requires more cochineal than common scarlet, because the acid of the composition in some degree lessens its stability. Secondly, for the same reason the colour always appears starved. Thirdly, the too great quantity of the composition hardens the wool and renders it more liable to spot, and therefore this method is probably the worst of the three. I have already said that the second method was attended with inconvenience on account of the necessity of using fustic, a wood prohibited for dyeing true colours, consequently the first method should have the preference, if the colour it produces be equal to that obtained from the second; but the colour of the yellow wood is not so solid as might be wished, as I know from experience, having exposed it to the sun. This seems rather extraordinary, considering that the ingredients are possessed of all possible solidity; but the following will account for their not answering in the present case:—

Cochineal, with the scarlet composition and cream of tartar, is so permanent that the lobster colour is scarce affected by the air. It is, however, different with regard to the yellow wood, for though very solid when the wood is boiled in alum

and tartar, especially if a little alum be added to the vat, it is nothing like so solid when the stuff has received the scarlet dye, which will not admit of alum; consequently, when these colours are exposed to the air they will very quickly crimson, that is to say, they will lose a part of the orange produced by the mixture of red and yellow; so that the air which fades every other colour seems to have a different effect upon this, which by being exposed becomes deeper and darker, because the air in some degree destroys the brightness of the orange. Its effects are nevertheless the same: for it is demonstrable from various chemical experiments that there exists in the air a vitriolic acid like that obtained from a decomposition of alum; for if you dip a lobster stuff in a slight solution of alum, the acid of this salt will immediately sadden the colour; if therefore the air be impregnated with the same acid, it will produce the same effect.

Very few shades are obtained from crimson and yellow, on account of the price of the former of these colours; especially as madder and kermes will produce the same shades. In the same manner orange shades may be produced with yellow and half-scarlet, and with yellow and half-crimson. These mixtures produce the various colours of *souci*, orange, gold, and such other shades as may be obtained from the mixture of yellow and red.

CHAPTER XXVI

Of the Mixture of Red and Fawn

The red of kermes or cochineal is seldom used for the colours resulting from this mixture, because for these kind of colours, which it is impossible to make lively on account of the fawn mixture, madder will be equally good. A fresh vat of cochineal and kermes is rarely prepared purposely, these ingredients being too dear for such common colours, and therefore it is sufficient, after maddering, to dip in an old decoction. If, therefore, when the stuff has been prepared with alum and tartar, proportioned to the madder red required, you dip it in a decoction of this root, as directed in Chapter XVII., and afterwards dip and stir it in another decoction of walnut root or husks, you produce the various colours of cinnamon, tobacco, chestnut, etc., which are obtained without difficulty by varying the madder ground, and according as they are suffered to remain in the decoction of this root. You may begin with either of the two colours, but it is most common to begin with the red, because the preparation absolutely necessary for the madder would in some degree hurt the fawn colour. Hence they should never be mixed together. Red and yellow are sometimes mixed.

CHAPTER XXVII

Of the Mixture of Red and Black

This mixture serves to produce dark reds of all kinds; but these are seldom used except for worsteds intended for tapestry. It is here necessary to recollect what I have said concerning greys, which may be obtained either from one vat, by putting into the copper a decoction of nutgalls and the solution of copperas, or from two, viz. by dipping the wool in a decoction of galls, and afterwards adding the copperas; but this method is rather embarrassing when a good assortment of patterns is required. The most convenient method is therefore to prepare a decoction of galls and copperas, as directed in the article concerning greys, and to dip the wool in it after it had been dyed red, with any ingredient whatever, till it becomes as dark as necessary. By this method you obtain dark scarlets, crimsons, and all other dark reds, let the shades be what they will.

This mixture produces also wine greys, by first giving the wool a slight tinge of red with kermes, cochineal, or madder, and afterwards dipping it in the darkening liquor for a longer or shorter time, according as you would have the wine colour predominate. I can give no further instructions concerning this process, as it depends upon the colour required; nor can it be supposed that anybody will find the least difficulty.

CHAPTER XXVIII

Of the Mixture of Yellow and Fawn Colours

This mixture produces the shade of the *feuille-morte* (withered leaf) and of the *poil d'ours* (bear's skin). It is pretty much the custom to use soot in these colours, instead of walnut husks or the root of the walnut tree, because it really gives a finer colour; but it is very necessary to scour the wool after it is dyed, in order to destroy the bad smell which it imbibes in this liquor. It is also necessary that the soot liquor should be clarified as I have before directed. I would always, nevertheless, prefer the walnut husks to soot; at least, if not obliged to make a very exact assortment of the *feuille-morte* shade, which could not be so well obtained with the husks or root of the walnut tree. These are the only two substances of any use in the fawn colour shades; sumach and the bark of the alder tree do not yield a sufficient ground. The wool should be boiled in alum and tartar, in order to dye it yellow, before it is dipped again in the fawn colour; but if you perceive that it has not had a sufficient basis, it may be dipped in the yellow, notwithstanding it has already had the fawn colour; though, to say the truth, this method of obtaining the precise shades does not produce a colour so solid as when it has first had a sufficient quantity of the yellow.

CHAPTER XXIX

Of the Mixture of Yellow and Black

The mixture of these colours is only useful when you require greys inclining to yellow; but these greys are much more easily produced with fawn colour, and the dyers generally prefer it, being more solid, more easily obtained, and at a much less expense. Besides, there is no occasion to boil the wool, which should be avoided as often as possible.

CHAPTER XXX

Of the Mixture of Fawn Colour and Black

From this mixture you obtain an infinite number of colours; such as coffee colour, maroon, prune, etc. The following is the manner of working:—When the wool or stuffs have been dipped in fawn colour, as already described, and that several shades are produced in succession, observing to give those intended for the darkest a greater proportion of the fawn colour, such as coffee colours, maroons, etc., you put into a cauldron nutgalls, sumach, and the bark of the alder tree, in proportion to the quantity of stuffs to be dyed. When the whole has boiled for an hour you add a little copperas. You then dip the stuffs intended for the lightest. As soon as these are finished you take them out and dip those which should be darker, carefully supplying the vat with copperas every time, in proportion as you perceive it necessary, which you will soon discover by its being longer in darkening the stuff. You continue in this manner, and with the same vat, till all the stuffs are darkened. The fire should be carefully kept in under the cauldron; but as the liquor should not boil, a slow fire is sufficient. Having first boiled the galls and other ingredients, you check the boiling with a little cold water before you put in the stuffs. This precaution, as I have several times observed, is absolutely necessary. You will also recollect that it is necessary to soak the stuffs in warm water before you put them into the cauldron, in case they

had been suffered to dry after they had the fawn colour dip, and that when they have remained some time in the darkening liquor it is necessary to cool them, passing them through the hands by the liftings, without which the stuffs would be in danger of being unequally dyed; besides, if not aired, the dark shade would not be sufficiently solid, because the successive congelation of the saline particles of the vitriol would not be accomplished.

Having thus considered all the colours and shades that could possibly be produced by a mixture of the primitive colours, by two and two, in which I think I have been sufficiently explicit, I now proceed, for the workman's advantage, to give him a specimen of such as I have obtained from a combination of the same primitive colours, by three and three. This mixture produces a great number. It is true that some of them will be found similar to those resulting from two only, there being few colours which may not be produced by various methods. The dyer will therefore prefer the least difficult when the colour is equally good.

CHAPTER XXXI

OF THE PRINCIPAL MIXTURES OF THE PRIMITIVE COLOURS BY THREE AND THREE

BLUE, red, and yellow produce ruddy olives and greenish greys and other colours of the same kind, of little use except for worsted designed for tapestry. I need not here repeat the method of using these colours, already sufficiently explained in the preceding article.

When the mixture contains blue, it is usual to begin with this colour. The stuff is afterwards boiled in the other colours successively. They are, however, sometimes mixed together, which is equally good, when each requires the same preparation, as, for instance, the red of madder and yellow. With regard to cochineal and kermes they are seldom used for common colours, unless for light ones requiring a vinous tinge, which should be bright and lively, and then only for the last dip, unless you require them more on the grey, when they should be dipped for the last time in the darker. It is, however, impossible to give any precise rules concerning this process, as the least experience will teach more than a long detail of operations.

Blue, red, and fawn produce olives from the darkest to the lightest; but the slate, lavender, and such like colours require but a very slight shade of red.

Blue, red, and black produce an infinite number of greys of all shades, as sage grey, slate, and lead colour, king and

prince's colour, when darker than common, besides a vast variety of colours, many of which run into those produced by other combinations.

Blue, yellow, and fawn produce greens and olives of all kinds.

Blue, yellow, and black produce all the dark greens, even to black.

Blue, fawn, and black produce dark olives and greenish greys.

Red, yellow, and fawn produce orange colour, gold colour, withered leaf, *carnations de veilliards*, burnt cinnamon, and tobacco colours of all kinds.

Red, yellow, and black produce colours something like the withered leaf.

Lastly, from yellow, fawn colour, and black you obtain hair colours, nut browns, etc.

This enumeration is meant only to give a general idea of the ingredients proper for the production of colours composed of several others.

Four of these colours may be mixed together, and sometimes five; but this is very uncommon. It is, however, needless to enlarge upon this subject, and therefore I shall relate only by what means I have myself seen forty different shades of carnations obtained. This example will be a sufficient guide in all other cases; but these shades include none of the lively colours belonging to scarlet, which are produced according to my directions in the chapter on that colour. All these carnations were meant for the flesh colour of old men and their shades, and were procured from the red of kermes, yellow, fawn, and black.

The dyer began by giving the worsteds an unequal preparation, reserving those which had the weakest for the lightest shade. Having remained four or five days soaked in the

preparation, as usual, he began by dyeing the lightest. The colours were disposed in four different vessels separately, and were kept as hot as possible without boiling. A skein of worsted was then dipped in the kermes vat, which, being taken out and expressed, was dipped in a decoction of weld, and a moment afterwards in the fawn colour, till it imbibed the shade required. Another skein was then immersed, which was suffered to remain a little longer in each liquor. In this manner the process was continued; but if any of the skeins, when expressed, appeared deficient in any of the colours, it was again dipped in that particular liquor. By this means all the colours had obtained the shades required; only such as were intended for the darkest shade were dipped in the darkening liquor. I am convinced by this process that patience and a little practice will produce all imaginable colours.

We cannot, however, be too urgent in recommending to begin with the lightest shade, because it frequently happens that when a skein is suffered to remain for too long a time in any one of these vats, it becomes necessary to put it among the darkest. But the lighter shades being once obtained in proper succession, there is no difficulty in producing the others.

What I have just described relates only to worsteds intended for tapestry, for which the utmost precision of shades is required, and without which it were impossible to imitate the painter's flesh colour. With regard to stuffs, a succession of shades is scarce ever attempted, or such a mixture of colours required, two or three being almost always sufficient, as these produce such a variety of colours that it is scarce possible to find names for them.

I have, I think, omitted nothing with regard to dyeing worsteds or woollens in the good dye; and I make no doubt but that by punctually observing my directions, both with

regard to worsteds, woollen fleece, and white stuff, the greatest variety of colours and shades imaginable may be executed in the highest perfection.

Nevertheless, I am of opinion that something should be added relative to mixed stuffs, that is to say, when the wool is dyed previous to its fabrication; and also some directions given concerning the method of mixing wools, dyed in different colours, to be afterwards carded and spun together, in order to form one colour resulting from a combination of the different coloured wools employed.

It will probably be said that this is more applicable to the manufacture of stuffs than to the method of dyeing them. To this I answer, that by sometimes mixing wools of different shades there is a possibility of obtaining colours which would be difficultly imitated by dyeing stuff in any one colour composed of these different shades; and that even some of these colours contain ingredients requiring a different preparation; but, on the contrary, that by dyeing each part of the wool separately, this mixture is produced without inconvenience. Be it as it may, I shall describe the method of mixing wool for the manufacture of mixed stuffs; and also the method of making felts in miniature, very necessary for the purpose of trying what combinations are productive of the most pleasing effect.

CHAPTER XXXII

The Method of Blending Wool of Different Colours for Mixed Cloths or Stuffs

A single example of the methods of blending several wools of different colours as accurately as possible will be sufficient, and may be easily applied in any other case when necessary. The following is the method practised in the manufactory of Languedoc, and pretty nearly the same method observed in other manufactories:—Suppose you want to make a mixed coffee-colour cloth, you dye 352 pounds of wool in this colour, which is called the wool of the basis, that is to say, the predominating colour of the stuff. You then take five pounds of wool dyed in the red of madder or kermes, and two pounds dyed a king's blue. These are called the mixing wools.

These wools are distributed to several women standing in a circle, about five or six feet from the manager, who stands in the midst of the circle with a stick in his hand. This process generally requires eight or ten, among whom the wool is entirely distributed. In the present case, for example, six of them carries the coffee-coloured wool for the basis, one the blue, and another the red. They are arranged in such a manner that three of them go first with the coffee colour, then the red, afterwards the other three with the remainder of the coffee colour, and at last the blue. When there is a greater number of colours they are distributed in the same manner.

When the women are thus disposed, they walk slowly

round the manager, observing always to keep an equal distance, and at every step to throw a small fleece at his feet, with this difference, that those who carry the red and blue, having but a very small quantity, throw very little at a time, whereas the others should throw a great deal more. Meanwhile the man keeps stirring the wool with his stick till the mixture is complete, when it is given to be carded.

This mixture is so perfectly finished by the cards that it is impossible to distinguish any one colour in particular. It is then spun, the cloth manufactured, and carried to the fulling mill. It is easy to conceive that this mixture should be very accurately made, for should the colours be unequal, the cloth would appear spotted.

As from the composition of these mixtures it is impossible to form an exact judgment of the effect produced by the combinations of their various colours in different proportions, I shall explain the method of making these experiments in miniature; and when you are content with the colour produced in this manner by a mixture of other colours in a known proportion, it may be executed at large, with a firm persuasion that the colour of the stuff will be equal to those of the patterns.

CHAPTER XXXIII

The Method of Preparing Felts for Trial

This little manœuvre is very simple but very useful, as by it you will be enabled to judge, in a quarter of an hour, what the stuff will be after it is manufactured, and even entirely dressed. For this purpose you take wool of different colours, and having accurately weighed each, the mixture is made with the fingers in what proportions you think proper; but the whole in such a small quantity, that the mixture when finished is no bigger than the size of your hand. It is then moistened with a little oil, and carded with small cards till the colours are blended together and perfectly well mixed; you then take this wool, which is exceedingly loose, and in the square shape of the cards; you fold this in four, and press it lightly between the hands. It is then dipped in a strong solution of soap in cold water; it is again taken out and squeezed hard between the hands at several times, sometimes clapping it from one hand to the other. It is afterwards rubbed lightly between the hands, by which means it is in some degree felted. It is again soaked in soap and water, and again fulled, till it has acquired a proper consistence resembling that of cloth. This felt is then a perfect pattern of what the cloth will be when manufactured; for if the wool has been properly spread in the hands after carding, and carefully managed, it will

be as even as cloth. To complete the resemblance after it has been washed, in order to cleanse it from the soap it should be dried and, having put it between two papers, pressed with a hot iron.

When satisfied with the colour of the felt, you proceed in the mixture for the cloth, observing carefully the same proportions, when there is no doubt but it will resemble the felt; for the different coloured wools are not only as well mixed in the felt as in cloth, but the soap used in the fulling produces also the same effect as the fulling mill with respect to the cloth. There are several dark colours, especially where there is a mixture of black and grey, which lose so much of their colour in the fulling that it is necessary to dye them a deeper colour than you intend they should remain. This defect in the darkening colour does not prevent it from standing the air; but, as I have already said, it is easily spotted with acrid liquors.

The colours darkened in the indigo and pastel vat lose nothing by fulling; hence they are never made darker than the colour required. The felts produce the same effect, and you may be assured that the stuff will lose no more by the fulling than the felt by soap and water; consequently this preliminary operation may be considered as a certain guide in the choice and assortment of wools for the composition of mixed cloth.

The felts are better made with black than with white soap; but it gives them a disagreeable smell, which is with difficulty washed off.

Felts may be also dyed when made, as in cases where you would have one colour cover all the rest: the stuff should then be mixed with the same colours as the felt, and dipped in the same dye; but this should be done only when the stuff has been fulled, shorn fine, and ready for dressing. This

method is useful when there is cochineal in the mixture, because when cochineal is required for mixed stuffs, you should have a fresh solution of it, in which the cloth should be dipped, when it has no other dressing to receive than what is given to a white cloth when it comes out of the dye.

CHAPTER XXXIV

The Method of Dyeing Woollens False Colours

I have observed in the beginning of this treatise that the art of dyeing woollens is divided into great, good or true, and lesser or false dye. The *Regulations* have determined the quality of the stuffs which ought to be dyed true, and of those which may be dyed false. This distinction is founded on this principle, that stuffs of a certain value, generally used for outside garments, require a colour more solid and durable than those of a lower price, which would necessarily become dearer, and more difficult to vend, if obliged to be dyed in the good dye.

I have related, with as much precision and accuracy as possible, the method of producing all imaginable colours in the good dye. I shall now proceed in the same manner with regard to false colours; and will teach the manner of producing the same colours with ingredients different from those which I have hitherto mentioned, and which, though they want the solidity of the first, have the advantage of being much brighter and more lively; they also give a more uniform colour, and with much greater facility.

I shall not in this species of dyeing observe the same order as for the true dye; because in this we know of no primitive colours, there being but few of them which serve as a basis to the others.

I shall now proceed in the following order, and shall begin with the names of the ingredients which ought to be particu-

larly preferred for dyeing false colours. I shall then give the manner of using each of these ingredients, and of obtaining the several colours they are capable of furnishing. Some of them yield colours so much alike that it were impossible to mention them separately, without tedious and embarrassing repetitions. The following are the ingredients hitherto known, viz.:—

Flock, or goat's hair maddered, archil, logwood, Brazil wood, fustic, the roucou, grains of Avignon, and turmeric. I shall in this place make no mention of saunders or soot, though ingredients particularly esteemed for dyeing false colours, having already given directions for using them in Chapter XIX. on fawn colours.

CHAPTER XXXV

Of Flock, or Goat's Hair

There are in the dyeing of flock, or goat's hair, two preparations very different from each other: the first is with madder, used for the good dye; the second, for its solution and use in false colours. The dye of goat's hair was formerly permitted for the good dye; but this was rather because it is a madder dye than from any experiment ascertaining its solidity. I know from indubitable trials that no colour fades sooner, for which reason doubtless it was confined by the new *Regulations* of 1737 to the dyeing of false colours. Nevertheless, as the same *Regulations* prohibited the use, or even the possession, of madder to the lesser dyers, it was enacted that none but dyers true should be permitted to madder hair, and the others to use it.

This maddering of goat's hair should have been mentioned in Chapter XVII. of this treatise, but I chose to relate in succession the operations which necessarily bear some affinity to each other, rather than to scrupulously confine myself to the distinction of the superior and inferior method of dyeing.

For maddering hair you take four pounds of cow's or goat's hair, well opened and divided, that the colour may penetrate the better. It should boil for two hours in a sufficient quantity of sour water; it should afterwards be put to drain for an hour, and then immersed in a middling cauldron, half-full of water, with four pounds of roche alum, two pounds of red tartar, and one pound of madder. The whole should boil for

six hours, adding hot water in proportion as the liquor wastes. It is then suffered to remain in this liquor all night and the next day. The third day it is taken out and put in a basket to drain; but some dyers leave it in the cauldron for eight days, though it is by this means often spoilt, part of the copper being corroded by the liquor. Having well washed these four pounds of maddered hair, you fill a middling copper two-thirds full, one-half sour, and the other half common water. When the liquor is ready to boil you add eight pounds of madder, well broken and rubbed between the hands. The madder being mixed in the liquor, you add four pounds of hair, letting the whole boil six hours. The hair is well washed, and the next day it is maddered a second time, and in the same manner, except that it requires only half the quantity of madder. After this second maddering it should be well washed and dried: it will then be almost black, and fit for use.

This operation shows that four pounds of hair has imbibed the colour of thirteen pounds of madder. Nevertheless there remains some colour in the liquid, which is therefore called an old madder vat, and is kept for particular occasions, as for tobacco colour, cinnamon colour, and several others.

When the hair is thus maddered by the great dyer, he sells it to the lesser, who has a right to dissolve and use it. It is dissolved in the following manner:—

Though this is the common method, it is attended with some difficulty, known only to a very small number of dyers.

At half-past seven in the morning you put six buckets of clean water into a common cauldron, and when the water is warm you throw into it five pounds of potash, well pounded. The whole should boil till eleven o'clock; but the liquor being considerably diminished, it should be removed into a smaller copper, taking care to let the dregs of the potash first settle. You then take a bucket of the liquor and return it into the

first copper, after it has been well cleaned, and a little fire put under it. The four pounds of maddered hair is then scattered in, by little and little, and at the same time a little addition of the warm saline liquor out of the small cauldron, in order to check the boiling.

When the hair is entirely dissolved and the liquor of the small cauldron put into the middling one, you throw a bucket of clean water on the dregs of the potash which remain in the little cauldron. This water serves to replenish the middling cauldron in proportion as it evaporates. The hair is entirely dissolved by the power of the potash, so that from the first half-hour not a single hair remains. The liquor then becomes a very deep red. The whole is boiled in this manner, without any addition, till three o'clock in the afternoon, that the solution of the hair may be entirely accomplished. You then fix a stick across the copper, on which you set a bucket of fermented urine ; but you should first have a little hole made in the bottom of the bucket, which should be filled with straw so that the urine may run very slowly into the copper. While it runs you make it boil hard, replenishing with urine what went off by evaporation. This operation lasts five hours, during which time it is supplied with three buckets of urine. When the ebullition is violent it should run through a stronger net than when it is moderate. You must observe that it is on account of the small quantity of the hair used for this experiment that it requires five pounds of potash ; but when you dissolve thirty pounds of hair at the same time, which is the quantity generally used by the dyers in Paris, you add only twelve ounces of potash to every pound of goat's hair.

During the whole of the operation you perceive a pretty strong smell of the volatile salt of the urine ; there is a constant scum on the surface of the liquor, which is at the beginning pretty brown, and becomes more so after the addition of the

urine. When it ceases to rise, and that the bubbles are small, the liquor is sufficiently done, which was the case in the present operation near eight o'clock in the evening. The fire is then taken away, the cauldron well covered with the lid and coverings, and in this manner it is left till the next day. Samples of the liquor were several times taken out, from three to eight o'clock in the evening, and bits of paper steeped in it. The first was very brown, but they became more and more light and uniform in proportion as the volatile spirit of the urine acted on the colouring particles of the solution.

There remains nothing more but to dye the wool in the liquor when thus prepared; it is called the melting of flock, and is the least difficult operation in the art of dyeing. You proceed in the following manner:—A quarter of an hour before you dye, you put into the solution a little bit of roche alum, very clean, stirring the liquor till it is dissolved. The liquor in the middling cauldron having been covered all night, and the fire not extinguished, it was still hot enough to burn the hand. The clearest of it was put into a small cauldron, with a sufficient quantity of warm water, and the wool, which had been first dyed with weld, being dipped in it, became a fine orange, inclining to fire colour; but this colour is much better produced in the good dye, as may be seen in Chapter XXV. of this treatise.

Twenty hanks of white wool are then dipped in the same vat, one after another, beginning with the darkest, and suffering them to remain for a longer or shorter time, according to the colour required. In this manner you produce a regular gradation, from nacaret to cherry colour. You should be attentive that in proportion as the liquor consumes, it should be replenished from the middling copper, and very careful not to stir the sediment at the bottom: you should be also careful to keep a little constant fire under the small copper, sufficient

to preserve the liquor of an equal heat. You proceed thus to dip the wool, till all the liquor is used and the colour quite exhausted. You cannot, however, possibly dye the light colours in this liquor, because when sufficiently exhausted for these colours it is generally loaded with impurities, by which these set of shades are deprived of their requisite vivacity.

This, therefore, is the method of producing colours lighter than cherry colours. You put five or six hanks of the darkest of the wool, which had been dyed with the flock, into a copper of clean water. The boiling water imbibes the colour of the wool; and in this fresh liquor the rest of the wool is dyed, from a cherry colour to the lightest flesh colour, observing always to begin with the darkest shades.

Dyers in general, who are either unacquainted with the method of melting the flock or unwilling to take the pains, buy some pounds of this scarlet of flock, which they boil in this manner for their palest colours, and which succeeds with great ease. But even this operation proves how little is to be depended on the solidity of a colour so easily discharged by boiling water. In fact, it is one of the worst colours in the art of dyeing, and therefore prohibited by the *Regulations*, except for the lesser dye.

It is evident, from this singular operation, that a very bad colour may be obtained from perhaps the very best ingredient in the art of dyeing. Madder is acknowledged as such; nevertheless, when this dyed hair, though with all the necessary precautions to confirm the colour as much as possible, is dissolved in a solution of potash, its colour, by acquiring additional brightness, loses all its solidity, and can be considered only in the class of the most unsteady colours.

One would imagine that the uncertainty of this colour might be attributed to the wool having received no preparation; but I have experienced the contrary, having dipped wools

prepared in the common and in various other methods, which, so far from having acquired a greater solidity, were even less bright than those which had had no preparation. Though I say that wool receives no preparation for the flock dye, it is nevertheless necessary that that designed for the light shades should be previously sulphured, the colour being thereby rendered more bright and lively, as the sulphur whitens the basis and cleanses it from all impurities ; but this is not usually practised, except for worsteds intended for work, or the fabrication of tapestry.

This operation is not, however, performed by the dyers themselves, on account of the smell and other inconveniences. Nevertheless, to give them some idea of this process, the white wool is hung upon rods over a chafing dish of coals, on which they sprinkle some powdered sulphur. The chamber door should be then shut, in order to confine the smoke till the wool is entirely whitened. This preparation gives vivacity to the rose, cherry, and flesh colour produced by the hair solution.

The reason of the little solidity of the colours of the madder root when obtained by means of the hair, may be easily accounted for. In the first operation of maddering the hair, as much as possible of the red colour is fixed by the alum and tartar; but being overloaded with colour it is easy to conceive that the superfluous atoms applied upon those previously received, the first are in fact the only ones retained in the pores of the hair and fixed by the salts. This colour, therefore, though very deep, would lose great part of its intensity by boiling in any liquor whatsoever, even common water ; but by the addition of an equal weight of potash to the hair already dyed, you consequently produce a very strong lixivium of fixed alkaline salt. I have already observed that alkaline lixiviums, when very powerful, destroys the natural texture of all animal substances, as also of gums

and resins. The lixivium of potash in the present operation is very strong and acrid; consequently a proper menstruum for the hair, which is an animal substance, and which it therefore instantly dissolves with a brisk fermentation. The natural texture of each hair is consequently destroyed; and at the same time the sides of the pores being broken and reduced to imperceptible particles, these sides have no longer either consistence or elasticity sufficient to retain either the salts or the colouring atoms which adhered to them. Therefore the animal particles of the hair, the colouring particles of the madder, and the alkaline salts of the potash being dissolved, form a new mixture which can no longer furnish a solid colour, because from all these saline particles there cannot form a sufficient quantity capable of crystallisation. In short, there is no possibility of its producing a vitriolated tartar, because it abounds too much with an alkaline salt.

To enliven the dusky dye of the madder applied to the hair, and afterwards dispersed by the solution of the hair in the mixture above mentioned, they add a considerable quantity of stale urine,—an additional circumstance to destroy all possibility of crystallisation, for it appears that wool, if not prepared with other salts, when steeped in a solution of this kind, will receive only a superficial colour, incapable of withstanding the smallest trials.

But wool even prepared with alum and tartar will imbibe from the solution of hair a colour no more solid than wool that had had no preparation of these salts. This is a singularity easily accounted for, for when a liquor abounding with fixed alkali encounters the remaining tartar of the preceding preparation, the tartar then changes its nature and becomes a soluble tartar.

It will be alleged, perhaps, that there remains in the pores of the prepared wool some particles of alum, and that these

particles of alum and some of this same salt, which were put into the solution of the hair, must form with the alkaline salt of potash a vitriolated tartar, capable, according to my principles, of fixing the colour. I answer, first, that the combination of the two salts requisite towards the formation of vitriolated tartar is prevented by the urine; and that though this impediment should not exist, the quantity of the salt formed will not be a sufficient gluten for all the pores of the wool, so as to enable them to receive and retain the colouring atoms. Besides, the alkaline salt in the liquor, by which the hair had been entirely dissolved, is still capable of dissolving the wool if boiled in it as long as the hair. Notwithstanding you do not give the liquor that degree of heat necessary for this total destruction, it is easy to conceive that though the sum of the destructive action be not the same, at least a part of it exists, or rather a fraction, which, though not a thousandth part, is still sufficient to corrode the sides of the pores of the wool, and to extend them in such manner as to render them incapable of retaining the colouring atoms. Add to this that the hair is dissolved in the liquor, and consequently mixed with the colouring particles of the madder; that the immediate contact of the colouring particles is impeded by the heterogeneous part, and that all these impediments uniting, conspire to render this the least solid of all the colours of the lesser dye. This is too plainly confirmed by experience, for a skein of worsted dyed red by means of the hair will be entirely discharged of its colour in boiling water.

CHAPTER XXXVI

Of Archil and the Method of Using It

Archil is a soft paste of a deep red colour, which by being simply diluted in hot water furnishes a great number of different shades; the most common sort, which is at the same time the least beautiful and the worst, is generally fabricated at Auvergne from a lichen or kind of moss very common on the rocks of this province. It is distinguished by the name of Auvergne or land archil; the other, which is called herb archil, or of the Canaries, or of Cape Verd, is much better. It is prepared at Lyons, at Paris, in England, and in other places.

The archil of Auvergne, called also Perelle, is a kind of crust or moss, gathered on the rocks. It is bruised and mixed with lime, and for several days sprinkled with stale urine. At the expiration of eight or ten days it becomes red by fermentation, and is fit for use.

The herb archil, which is the *lichen grœcus, Polypoides tinctorius sexatilis*, Corall. 40, on the *Fucus verucosus tinctorius*, J. B. 3. Inst. R. herb. 568, etc., grows in the Canary Islands, close to the rocks, and chiefly upon those which are nearest the sea. All these islands produce archil, but that which grows on the islands of Gomer and Fer is accounted the best. It is a dark thriving plant, with little white spots on the top. [*Memoirs of M. Porlier, Consul*, dated from Sainte Croix of Teneriffe, the 29th of Jan. 1731.] One year with another

they gather on the isle of Teneriffe 500 quintals; 400 at the Canaries; 300 at Fuerta Ventura; 300 at Lansarotto; 300 at Gomer; and 800 on the isle of Fer.

The archil of Teneriffe, the Canaries, and Palene is farmed out by the King of Spain to particular people. In the last place, in 1730, they farmed it at the rate of 1500 piastres, and besides paid from fifteen to twenty reals per quintal to the gatherers. The other islands belong to different powers.

Archil was formerly worth no more at St. Croix, in the island of Teneriffe, than three or four piastres the quintal; but since the year 1725 you can scarce buy it for ten, the demand for it being so great for London, Amsterdam, Italy, and Marseilles. In 1730 it was sold in London at four pounds sterling the quintal.

Archil is also produced in the Madeiras, Porto Santo, etc.

Near the latter end of the year 1730 the captain of an English vessel, who came from the Cape de Verd Islands, brought a bag of archil to St. Croix as a sample. He communicated his secret to some Spanish and Genoese merchants, who in the month of July 1731 manned a vessel with eight Spaniards accustomed to gather the archil, and sent it to the same islands. They landed on the islands of St. Anthony and St. Vincent, where they found it in great abundance, and in a few days completed a freight of 500 quintals of this plant, without any other expense than a single piastre per quintal as a present to the governor. The archil of the Cape Verd Islands appeared larger, longer, and better than that of the Canaries, probably because it was not the custom to gather it every year as at the Canaries.

Those who prepare the herb archil make a mystery of this preparation; but it is pretty accurately described in a treatise of M. Pierre Antoine Micheli, called *Nova Plantarum genera* (printed in 4to, 1729, p. 78), in these words:—

"*Infectores (Florentina) hanc plantam appellant vernaculo nomine* Rocella *vel* Orsella, *vel* Raspa, *ejusque ope sericum and lanam, non solum peculiari quodam colore sub purpureo imbuunt, quem*Columbinum *vocant, ob similitudinem cum collo Columbino, sed etiam aliis compositionibus admiscent, ut diversos colores efficiant, præparant vero illam hoc modo : Plantam in pulverem adeo tenuem reducunt, ut per cerniculum facillime trajiciatur. Deinde, vetere Maris urina (nam mulieris perniciosa habetur) leviter illam irrorant vase ligneo contentam, and semel in die agitant ; atque eodem tempore in eam demittunt aliquantulum cineris ex soda donec, expleto opere, ejus quantitas singulis diebus immissa, ad quantitatem pulveris, sit in ratione* 1 *ad* 12, *sive plus, sive minus ; prout planta est magis crassa vel tenuis, vel recens, vel vetus : idque fit, donet totum compositum prædictam Colorum Columbinum exhibeat. Postea ligneo doliolo reponunt, and urinam vel lixivium calcis, aut gypsi, quo dealbantur parietes, super infundunt, ut tota quantitas contegatur, and ad usum servant. Compositionem hanc vocant* Oricello, *forte a nomine plantæ* Rocella. *Suspicari subit nonnullas hujus generis plantas, eodem vel alio modo præparatas, eundem Colorem vel alium præbere posse. Quod nunc innuisse sufficiat, ut instituta experimenta ad has cogitationis deducant.*"

In a little Italian book (*Dell'-arte Tinctoria* or *Plicto,* small 12mo, p. 210) the preparation of archil is described in the following manner :—"Take one pound of the orseille of the Levant, very clean; moisten it with a little urine; add to this sal-ammoniac, sal-gemmæ, and saltpetre, of each two ounces; pound them well, mix them together, and let them remain so during twelve days, stirring them twice a day; and then, to keep the herb constantly moist, add a little urine, and in this situation let it remain eight days longer, continuing to stir it; you afterwards add a pound and a half of potash,

well pounded, and a pint and a half of stale urine. Let it remain still eight days longer, stirring it as usual; after which you add the same quantity of urine, and at the expiration of five or six days, two drachms of arsenic; it will be then fit for use.

In imitation of this process, rejecting what I thought useless, I put half a pound of the orseille of Cape Verd, hacked or cut very small with a pair of shears, into a glass vessel with a stopper. I moistened it with some fermented urine. I then added a sufficient quantity of slaked lime, for this first time about an ounce. I stirred this mixture well every two hours for the first day. The next day I added a little more fermented urine and a little lime, stirring it four times the second day. The orseille grew purple, but the lime remained white. The volatile alkali which exhaled when uncovered was very penetrating. The third day I put a little more urine, a little lime, and stirred it four times during the day. The fourth day the lime began to take a purple colour; in short, it became entirely a light purple at the end of the week, and during the next week it became darker and darker in such a manner that at the fortnight's end it was fit for use. But as that which was prepared by Lafond with permission has a violet smell when sold, I kept mine in a covered vessel during a month to let the urinous volatile spirit evaporate. At the expiration of three weeks I perceived, when the vessel was uncovered, the violet smell, and the small quantity of the liquor remaining at the bottom of the vessel had acquired a very beautiful crimson. In this manner it is possible to prepare the archil with urine and slaked lime only, especially if intended to be made into paste, without the addition of the other ingredients mentioned in the above process. To develop the red colour concealed within this plant by a urinous volatile spirit, excited by a terreous alkali, is all that is required.

I have at the same time, and in the same manner, prepared a pound of *perelle*, or *orseille de terre*, from the Auvergne rocks, which at the expiration of the week had imbibed a tolerable deep colour, was much darker at the end of the fortnight, when I dyed a sample, and succeeded perfectly well.

To ascertain the good effect of the archil, the dyer spreads this paste a little moistened on the back of his hand, where he leaves it dry, and afterwards washes the spot with cold water. If the spot remains discharged only a little, he concludes his archil to be good.

The lichen *Tinctorius sexatilis* is not the only plant of this genus capable of being made into archil; there are several other kinds of moss that produce a tolerable fine red. Mr. Jessieu brought me some from the forest of Fontainebleau, which with lime and urine took a purple colour. There is an easy method of trying which of them will undergo this change.

I put about three drachms of this plant into a small glass vessel. I moistened it with volatile spirit of sal-ammoniac, and an equal quantity of the lime water; to this I added a pinch of sal-ammoniac, and then covered it close with a wet bladder tied round the vessel. If the lichen be of a colouring nature, the small quantity of liquor which, by inclining the vessel, runs from the plant, will have imbibed a fine deep crimson, and the liquor afterwards evaporating, the plant itself will be of the same colour. If neither the plant nor the liquor is coloured, you have nothing to hope for, and it were in vain to attempt a larger preparation.

I now proceed to the method of using the orseille or archil; but I shall speak only of the *orseille d'herbe* or Canary, noting only the difference in using that of the Auvergne. You fill a cauldron with clear water, and when it begins to grow warm you put in as much of the archil as you think proper, in pro-

portion to the quantity of wool or stuff to be dyed, and to the shade you would give them. You then heat the liquor till it is ready to boil, and dip the stuffs without any other preparation, only leaving those intended for the darker a longer time. When the archil furnishes no more colour you heat the liquor till it is ready to boil. The colour obtained in this manner from the *orseille de terre*, or *d'Auvergne*, is more dull than at the first heating ; but, on the contrary, the herb archil loses nothing of its brightness though kept boiling from the beginning. The last is in fact dearer, but it yields much more colour ; consequently the use of it is more advantageous, even though you should not consider its superior goodness and beauty. The natural colour of each archil, obtained in this manner, is a fine *gris-de-lin*, inclining to violet. You may also procure from it the violet, the *couleur de pensee, de amaranthe,* and other such colours, by previously giving the stuffs a basis of blue.

You will observe that to make the light shades of these colours as bright as possible, they should be previously sulphured, as in the preceding chapter.

This is the simplest method of using the archil ; but the colours resulting from it have no solidity. One would be inclined to think that it were better to give the wool and stuffs a previous preparation, as for the good dye, either with madder, cochineal, etc. I am, however, convinced of the contrary, having tried the preparation of alum and tartar without any effect.

There is, nevertheless, a method of giving the herb archil almost as much solidity as of the good dyes ; but then you destroy its natural colour, viz. *gris-de-lin,* instead of which it produces red, scarlet, or rather the colour distinguished by the name of half-scarlet. It also produces the colour of kermes, Venetian scarlet, and several other shades upon the

red and orange. These colours are procured from the archil by means of acids, and should be considered as much more solid than the others, though not strictly *in grain.*

There are two methods of obtaining these red colours from the orseille. The first is to incorporate an acid in the composition used for making this plant into paste, called by the dyers archil. I have been assured that it is possible to make it violet, or even blue, which is probably produced by a mixture of some alkali; but I confess that, notwithstanding upwards of twenty trials for this purpose, I could not succeed. I will therefore proceed to the second method, by which I myself obtained a fine red, and tolerably solid, having tried it four times with success.

You take the prepared orseille of the Canaries, diffusing it as usual in warm water, and add to it a little of the common scarlet composition, which is a solution of block tin, in *aqua-regia* diluted. This acid immediately brightens the solution, and gives it a scarlet colour. The stuff or wool is then dipped and suffered to remain in it till it has acquired the shade you would choose. If the colour be not sufficiently fiery, you add a little more of the composition; but for this species of dyeing you pursue pretty much the same method as for common scarlet. I endeavoured to accomplish it by two dippings in dyeing scarlet, that is to say, to boil the stuff with the composition and a little archil, and to finish it afterwards with a greater quantity of each, in which I succeeded equally; but the operation is more tedious, and I sometimes obtained as good a colour from one dipping only.

I cannot exactly determine the precise quantity of the ingredients in this operation; first, because it depends on the shade required; in the second place, because it is a new process in the art of dyeing, and because I have not, in this manner,

had occasion to dye a sufficient quantity of stuffs. It is also known that the success depends in some degree upon the quantity of acid in the composition. Lastly, this method of dyeing with the archil is so easy, that as soon as you have made two or three trials, even in miniature, you will know more than I can possibly teach by the most elaborate description. I need only observe that the more the colour of this ingredient inclines to scarlet, the more solid it is. I have myself procured a great number of different shades, entirely obtained from the same archil, and which consequently differed only in proportion to the quantity of the composition, and I have always observed that the more the archil differs from its natural colour, the more solidity it acquires; so that when I brought it to the degree of half-scarlet it withstood the action of the air and trial as well as those which are produced by cochineal and madder.

If you put too much of the composition the wool becomes of a disagreeable orange colour; but it has the same effect with cochineal, consequently is not an evil peculiar to this species of dyeing; it is, besides, very easily avoided. As it is always in your power to add more of the composition, it is best to begin with a little rather than run any risk by putting too much.

I attempted to substitute various acids for the composition of scarlet, but none of them had so good an effect. Vinegar never gave the liquor a sufficient redness, and the stuff dyed in it imbibed only the colour of lees of wine, which faded even as soon as the colour obtained from the archil in its natural state. Other acids made the colour dull. In short, it seems evident that it is necessary to unite with the red of archil, in the same manner as with the scarlet of cochineal, a metallic basis extremely white. This basis is the calx of tin existing in the composition.

I have repeated the same operation with the archil of Auvergne; but the colours resulting were by no means either so good or so fine, and therefore what I have said should be understood only with regard to the herb archil, and especially of that fabricated at Paris by the sieur Lafond.

CHAPTER XXXVII

Of Logwood

Logwood is an ingredient very much used in the lesser dye; and it were greatly to be wished that it were not also used in the great, which is too frequently the case, because the colour furnished by this wood very soon loses all its brightness when exposed to the air. Its cheapness is one reason why it is so often used; but the strongest reason is, that by means of different preparations and different salts, this wood produces a very great variety of colours and shades, which are with difficulty obtained from the ingredients of the good dye. It is, however, possible to obtain all their colours without logwood.

You have seen in Chapter XX. that logwood is necessary for softening black and making it velvety, which constitutes the excellency of the Sedan blacks; I therefore refer you to that chapter, having nothing more to add concerning the use of logwood with regard to black. I have there informed you that the blacks are finished by the inferior dyers. I shall now treat of other colours in which logwood is used, premising once for all, that when using wood of any kind, it should be cut very small and tied in a linen bag, as the chips might not only tear the stuff or wool, but would spot wherever they adhered; consequently this precaution is absolutely necessary.

Logwood is used with galls and copperas for the various shades of greys, inclining to slate, lavender, dove, and lead colour, etc. For this purpose you fill a cauldron full of clean

water, putting into it as much nutgalls as you think proper, according to the quantity of stuffs to be dyed and to the shade required. You then add a bag of logwood, and when the whole is boiled, having cooled the liquor, you immerse the stuff, throwing in by degrees some copperas partly dissolved in water. I cannot determine the quantity of these ingredients, as it is the custom with inferior dyers to use them by guess, and as their business generally consists in matching stuffs intended for linings to cloths, of which they receive patterns, they begin by making them at first lighter than they should be, and then darkening them to the shade required by the addition of copperas. When they perceive a deficiency of logwood they add more afterwards. This is their method when they have different shades to procure from the same liquor, and when the colour is exhausted. You will easily perceive that there is no difficulty in this process, and that it requires only practice to be tolerably exact with regard to the necessary quantities of the ingredients, and to know by the stuffs when wet, whether they will have the colour required when dry.

There is in all colours a pretty certain method of ascertaining whether the stuff will match the pattern when dry, which is by wringing a little corner very hard, and blowing upon it with some violence. You will instantly perceive the colour it will have when dry; but it is necessary to judge immediately, else the surrounding moisture returning to this dry part, you may be deceived.

You may also procure a tolerable violet colour from this wood, by boiling the wool as usual with alum and tartar, and afterwards dipping it in the decoction of logwood, with the addition of a little alum dissolved. But you will obtain a much finer colour by previously woading the stuff, aluming it afterwards, and then dipping it in a decoction of Brazil wood

mixed with a little logwood, because the blue basis always remains, and in some degree preserves the colour.

Logwood will also produce a blue, but it has so little solidity and the indigo is so cheap, when not very deep, that logwood is seldom used. Nevertheless, if you would try it merely for curiosity, you need only prepare a decoction of logwood mixed with a little blue vitriol, and dip the wool, without any other preparation.

You may also by this means produce greens. [*I may add to the number of these false greens, that are called Saxon green, so much esteemed in late years in Germany, as being more beautiful and much brighter than any of the greens hitherto produced, either true or false ; but it withstands no trials, and if exposed to the sun for twelve days, loses more than half its intensity.*

The composition, such as I received it from Germany, is made thus : You put into a glass matras three parts of best indigo, three parts cobalt, three parts orpiment, and twelve parts rectified oil of vitriol. This produces a violent fermentation, and an effluvium which should be avoided ; after twenty-four hours' digestion you pour off the liquor, by inclination, into a separate vessel, which liquor is a very deep blue.

You may substitute antimony instead of cobalt, cobalt being much dearer and scarce in France. In short, M. Baron, Doctor of Physic, who in compliance with my request made various experiments with the composition, found that the orpiment, the cobalt, and the antimony might be omitted, and that the oil of vitriol poured on the indigo is, without any other addition, sufficient to produce a blue composition as fine as the preceding.

The cloth should boil in a quarter of its weight of alum, to which you may add, if you please, a very small quantity of tartar : it should remain moistened with this preparation for three days, and should afterwards be washed.

The water should be heated till ready to boil, pouring into it a small quantity of the blue composition; when the liquor instantly becomes of a light blue. Dip the prepared cloth, stirring it, without suffering it to boil. When it has imbibed a sky blue, take it out and plunge it into another cauldron, containing a yellow infusion of turmeric *well pulverised: this infusion should be hot, but not boiling. The cloth will imbibe any green shade you please, by keeping it in the liquor for a longer or shorter time. To save a second fire, the* turmeric *may be put into the first liquor, after the blue had been exhausted, and it will have the same effect.*

Though silks are out of the question in this treatise, I cannot avoid observing that they may be dyed blue and a very beautiful green in the same manner, with the greatest facility] in one liquor only. For this purpose you put French berries and verdigris into the logwood cauldron; this mixture gives a fine green colour. It is then sufficient to dip the stuffs till they have imbibed the colour required. You will perceive that you may make this green of what shade you please, by proportioning the quantities of the logwood and French berries. This green is no better than the blue, and should each of them be banished from the art of dyeing. I have given the process only because I would omit nothing within my knowledge concerning this art.

The most common use of logwood in dyeing false colours, is chiefly for prune and purple, and their several shades. This wood, with the addition of nutgalls, gives these colours to blued wool with great facility. This may be browned occasionally with a little copperas; by this means you easily obtain shades which are with much more difficulty produced in the good dye, because the different degrees of darkening to your mind are not so easily procured in the blue vat as by the help of copperas. But these colours fade almost immediately, so that

in a very few days there is a great difference between the parts exposed to the air and those which remain covered.

Having demonstrated in the preceding chapter that the scarlet composition changed the colour of the archil, making it more solid, I determined to try its effect upon logwood; but though I put ever so much, the logwood liquor still retained its violet colour. I thought this strange. Nevertheless, determining to reduce this experiment to something practicable, I dyed a bit of cloth with the logwood, adding to the liquor as much of the composition as I should have put to the same quantity of the archil. My cloth took a tolerable good violet colour; but by exposing it to the air for twelve summer days, I was convinced that it was no better for the composition. By adding a small quantity of the crystals of tartar in another decoction of the same kind, I had indeed a more solid colour, though considerably different.

CHAPTER XXXVIII

Of Brazil Wood

Under the general denomination of Brazil wood is comprehended that of *Fernambouc*, of *Sainte-Marthe*, of *Japan*, and some others needless to be distinguished in this place, as they are used in the same manner. Some of them, it is true, give more colour and better than the other; but this is frequently occasioned by some parts of the wood having been more exposed to the air than others, or perhaps in some places rotten. That which is the most sound and the highest coloured should be preserved for the use of dyeing.

All these woods give a tolerable fine colour, whether used alone or mixed, either with logwood or any other colouring ingredient. We have just seen that for false violets a little Brazil wood is added to the logwood; but for wine greys, or for colours ever so little inclining to red, much more is required. A very little nutgalls with the Brazil is sometimes sufficient if darkened with copperas; but logwood, archil, or some other substance is frequently added, according to the shade required. Hence it is obvious that there is no possibility of prescribing any positive rule for this kind of process, on account of the almost infinite diversity of shades obtained from these different mixtures.

The natural colour of Brazil wool, and for which it is most frequently used, is for false scarlet, which is nevertheless a

fine colour, though inferior to the scarlet of cochineal or gum-lac.

To obtain the colour of this wood you must make use of the hardest well water; river water has by no means the same effect.

Having boiled this wood, cut into chips, in the first water for three hours, the liquor is poured into a cask. You then pour on the Brazil wood some fresh well water, and letting it also boil for three hours, you pour this water also to the first liquor. This decoction, called the juice of the Brazil wood, should grow old, ferment, and rope, like oily wine before it is used. In order to obtain from this wood a lively red, it is necessary that the stuffs should have the common preparation of salts and alum, only the alum should predominate, as the beauty of this colour is greatly impaired either by tartar alone or by sour waters; in a word, acids injure it by dissolving the red particle. Hence it is necessary to put into the liquor from six to eight ounces of Roman alum for every pound of wool or stuff, and but two ounces of tartar, or even less. The wool should boil in it for three hours; it should then be lightly expressed, and kept moist in a damp place for the space of a week, that the salts may be sufficiently lodged so as to prepare it for the reception of the colour. For the dyeing, you put into a proper sized cauldron one or two buckets of the juice of Brazil wood, very old, in which you dye some common stuff that had been boiled in alum and tartar. This coarse stuff being dyed, you replenish with fresh Brazil juice, only half the quantity of the former, boiling in it a second piece of common stuff prepared in the same manner. These two stuffs must necessarily imbibe three-quarters of the colours. The decoction being thus weakened, you dip the piece of stuff that had been kept in the preparation for eight or ten days, stirring it well, without letting the liquor boil too much, till it is uniformly

dyed. But, as I have already said, you must mind to wring a corner of the stuff every now and then, in order to judge of the colour, for it appears at least three shades darker when wet than when dry. By this method, rather tedious indeed, you obtain very fine lively reds, a perfect imitation of certain colours sold by the English for logwood scarlets, and which, tried by the *débouillis,* are no better than these, were it not that they seem as if they had been slightly maddered. The red I have just mentioned, and nowhere else described, will withstand the air during the winter without losing any of its shade; on the contrary, it grows darker, and seems to acquire depth, but it will not resist the tartar liquor.

Some of the great dyers use Brazil wood to heighten their madder reds, either to save the root or to give its red more vivacity than usual. This is performed by dipping a stuff began with madder in the Brazil liquor; but this fraud is expressly prohibited by the *Regulations,* as well as all mixture of true and false colours. The first colour obtained from the Brazil wood is never *solid*; because it is an ill-digested sap, and the colouring particles not sufficiently attenuated to enter the pores of the wool. When the first gross particles of the colour have been imbibed by the common stuff, as above described, those which remain are finer; and mixing with the yellow ligneous particles, the red resulting from it is much more solid.

By the addition of acids of any kind, the red colour of this wood may be entirely destroyed; and in this case the stuff dyed in it takes a hind colour of in proportion to the time of its immersion; and this colour is perfectly premanent.

It is said that the *Amboise* dyers have a method of fixing the colour of the Brazil wood. After their stuffs are lightly reddened with madder and dipped in a weld liquor, consequently twice boiled in alum and tartar, they put to the Brazil

juice a sufficient quantity of arsenic and potash, and then they say that this colour is capable of withstanding all trials. I have myself tried this process, but without success.

If you do not require a very bright red from the Brazil wood, I know from experience that it is possible to fix these colours in such a manner that, having this summer exposed them to the sun for thirty days, they were not altered. But these are coffee colours and maroon purples.

In order to produce these colours I kept the stuff for a fortnight moist with the preparation, composed as for the reds before mentioned, in a vault. I filled a copper two-thirds full of well water; I then filled it up with the juice of the Brazil wood, adding of Aleppo galls, very finely powdered, about an ounce to every pound of stuff, and half the quantity of gum arabic; let it boil an hour and a half or two hours, according to the shade required. It was aired from time to time, and when it had imbibed the colour I wished, I let it grow very cold before it was washed. This stuff when brushed, sheered, and put in a cold press, was extremely fine, very even, and perfectly well finished.

CHAPTER XXXIX

Of Fustic

The fustic wood gives an orange colour, but without solidity. It is generally used for the inferior dye in the same manner as the root of the walnut tree, or walnut husks without boiling the stuff, so that there is no difficulty in using it. To produce tobacco, cinnamon, and such like colours, it is frequently mixed with walnut husks and weld. But this wood should be considered as a very bad ingredient, as its colour, by being exposed for a very short time, loses all its brightness and a great part of its yellow shade.

By dipping a stuff dyed with fustic into a blue vat, you obtain a very disagreeable olive colour, which will not stand the air, and which in a very little time becomes ugly.

I have already said that it is used in Languedoc for producing the lobster colours exported for the Levant in order to save cochineal. For this purpose they mix fustic, weld, and cochineal with a little cream of tartar in the same decoction; the stuff boiled in this imbibes a lobster colour, and is more or less red, or more or less orange, according to the quantities of the different ingredients. Though the practice of mixing ingredients of the good dye with those of the false be blamable, it appears, however, that in this case, which is very rare, and for this colour only, being frequently required for the Levant trade, the use of fustic may be allowed; for having myself endeavoured to produce the same colour with grain

ingredients only, the colour thereby obtained had no more solidity.

The alteration produced on the lobster colour obtained from fustic is very perceptible, but not so disagreeable as the changes frequently produced on several other colours; for the entire colour being faded and defaced at once, it is rather a diminution than a change of colour, whereas the lobster colour obtained from yellow wood becomes a cherry colour.

CHAPTER XL

Of Roucou

The *roucou,* or *raucourt,* is a kind of dry paste imported from America. This substance yields an orange colour something like fustic, nor is it more solid. We must not, however, judge of the quality of the roucou by the alum trial, which, so far from injuring its colour, makes it more bright and much finer; but the air fades it in a very short space of time. Soap has the same effect, and is indeed the proper trial to judge from, as prescribed by the instructions. This substance is easily supplied for true colours by the weld and madder mixed together; but for dyeing false colours, roucou is used in the following manner:—

You dissolve some potash in a copper with a sufficient quantity of water; it should boil well for an hour, that the salts may be perfectly dissolved; you afterwards add to it an equal quantity of roucou, stirring it well and letting it boil for a quarter of an hour. You then dip the wool or stuffs, without any other preparation than moistening them in warm water, that they may imbibe the colour equally. They remain in this liquor, constantly stirring them, till they have imbibed the shade required, after which they are well washed and then dried.

Roucou is frequently used with other ingredients for dying false colours; but I can give no instructions concerning this

mixture, as it depends on the shade required, and is attended with no difficulty.

I tried the preparation of alum and tartar previous to the stuffs being dyed in the roucou ; but though they had acquired a little more solidity, they were not sufficiently solid to be reputed true. Roucou is in general a very bad ingredient for dyeing wool, and not much used, being very dear, and easily supplied by much cheaper and more tenacious ingredients.

Wool dyed in the roucou, and afterwards dipped in an indigo or woad vat, takes a reddish olive colour, which in a short time becomes almost entirely blue; because the colour of the roucou disappears.

CHAPTER XLI

Of French Berries

French berries are very little used in the art of dyeing. They produce a tolerable good yellow, but which is no more solid than the green which they give to wool that had previously received a basis of blue. The stuff should be first boiled in alum and tartar, as for weld. You then prepare a cold infusion of French berries, in which the stuff is dipped and left till it has acquired the shade you would choose. There is no difficulty in the use of these berries, and therefore I shall say no more of them, observing only that they should never be used but when there is an absolute want of all other ingredients for dyeing yellow. They are neither scarce nor dear.

CHAPTER XLII

Of Turmeric

Turmeric is a root imported from the East Indies; that which comes from Patna is the most esteemed. The Indian dyers call it *Baleli*. Mr. Colbert's *Regulations* call it *Concomme*. It should be reduced to a very fine powder, and used much in the same manner as the French berries, but in less quantity, because it yields a great deal more colour. It is not quite so bad as the ingredients for yellow mentioned in the preceding chapter; but it is dear, consequently seldem used for dyeing false colours.

It is sometimes used for brightening the gold colours obtained from weld, and for oranging the scarlets; but this practice is blamable, for in a very little time the colour of the turmeric fades, so that the gold colour is left in its former state, and the scarlets become considerably darker. Whenever this happens, we may certainly conclude that these colours have been falsified with this ingredient.

I shall make no mention of real saffron, which I believe is never used; in the first place, because it is too dear, and secondly, because its yellow is even less permanent than either of the preceding.

I have nothing more to add concerning the ingredients for dyeing false colours; they should never be used but for common or low-priced stuffs. I do not, however, think it impossible to obtain solid colours from them; but then these

colours would not be the natural colour of the ingredient, as it would be necessary to supply them with the astriction and gum in which they are deficient, the arrangement of particles would not be the same, consequently the rays of light would be differently reflected.

CHAPTER XLIII

INSTRUCTIONS FOR THE PROOF-LIQUOR FOR WOOL AND WOOLLEN STUFFS

As it has been acknowledged that the method prescribed for the proof-liquor of the dyers in the XXXVIIth article of the *Regulations* for true dyers, August 1669, either in cloth, serges, etc., and also in the articles CCXX., etc., of the general *Instructions* of the 18th of March 1671, for dyeing of wool all kinds of colours, and for the cultivation of the drugs and ingredients used, is not sufficient to authorise a positive decision concerning the goodness or deception of several colours; but that this method may even sometimes lead us into an error, and give rise to disputes, his majesty has ordered various experiments on worsted designed for tapestry, in order to ascertain the goodness of each colour, and also the proof-liquors best adapted to them.

For this purpose some fine worsteds were dyed all manner of colours, both true and false; and for a proper time exposed to the weather. The good colours were perfectly established, and the bad ones more or less faded, in proportion to the badness of their quality. No colour can be reputed good, but in proportion as it withstands the weather: this trial served as a rule with respect to the goodness of different colours.

Other patterns of the same worsted were afterwards tried in various proof-liquors; it immediately appeared that the same ingredients would not answer for all colours, because

it sometimes happened that a colour capable of resisting the weather was very considerably injured by the proof-liquor, and that some false colours withstood the same proof-liquor.

From these experiments we learn the inutility of lemon juice, vinegar, sour water, and *aquafortis*, on account of the impossibility of ascertaining their degrees of acid; but the most certain method appears to be in the use of such ingredients, as with common water, constantly produce the same effect.

In the pursuit of this object it has been thought expedient to divide the various colours, in which it is possible for wool to be dyed, into three classes, whether true or false, and to ascertain the ingredients proper to be used in the proof-liquors of the various colours comprehended under each of these three classes.

The colours comprised in the first class should be tried by a solution of Roman alum, those of the second by white soap, and those of the third with red tartar.

It is not, however, sufficient, towards ascertaining the goodness of a colour by the trial of these solvents, to employ ingredients always producing the same effect; but it is also necessary, not only that the precise time of this operation should be exactly determined, but also that the quantity of the liquor be fixed, because the activity of the ingredients will be considerably augmented or diminished in proportion to the quantity of water; but the method of proceding with regard to the different proofs is prescribed in the following articles:—

ARTICLES

I. The solution of Roman alum is made in the following manner:—

You put into an earthen vessel a pint of water, with half

an ounce of alum. The vessel is then set on the fire, and when it begins to boil fast, you put in the wool for trial, letting it boil during five minutes; it is then taken out and well washed in cold water. The pattern should weigh one drachm, or thereabouts.

II. When you have several patterns of wool to be tried together, it will be necessary to double, or even to treble the quantity, both of the water and alum, which will not in any respect alter the strength or efficacy of the solution, observing always to put half an ounce of alum to every pound of water.

III. To render the effect of the solution more certain, you should observe not to boil different coloured wools together.

IV. The white soap solution is made in the following manner:—

You put into a pint of water only two drachms of white soap sliced; having afterwards put the vessel on the fire, it should be stirred with a stick, to facilitate the solution of the soap. When it is dissolved, and that the water boils fast, you put in the pattern, which should boil in the same manner for five minutes exactly; but this should not be done till the water boils fast.

V. When you have many patterns you proceed in the same manner as in the second article, that is to say, two drachms of soap to every pint of water.

VI. The liquor, with red tartar, is made in the same manner as with alum, observing only that the tartar be well pounded before it is put into the water, and that it be entirely dissolved before the patterns are put in.

VII. The following colours should be tried with the solution of Roman alum, viz: all crimson shades, Venetian scarlet, fire-colour scarlet, cherry colour, and other scarlet shades, violets, and *gris-de-lin* of all shades, purples, lobster colour

pomegranate flower, blues, slate colours, lavender greys, wine greys, and all shades of the same kind.

VIII. If, contrary to the *Regulations* for dyers, they have used false ingredients for dying fine wool crimson, the counterfeit is easily discovered by the alum solution, which only violets a little the true crimson, but destroys the highest crimson shade, if false, reducing it to a pale flesh colour; it almost entirely discharges the common shades of the false crimson. Hence this solution is a certain method of distinguishing the inferior crimsons from those in grain.

IX. The scarlet of kermes, commonly called Venetian scarlet, is in no respect injured by this solution; it purples the fire colour, and converts the inferior shades to violet; but it almost entirely discharges the counterfeit scarlet of Brazil wood, reducing it to the colour of an onion peel; it has still a more evident effect on the fainter shades of this counterfeit colour.

The scarlet of flock is almost entirely discharged by this solution.

X. Though the violet is a compound colour, formed of blue and red, it is nevertheless of so much importance as to deserve a particular inquiry. The solution of alum and tartar has scarce any effect on this colour if true; but, on the contrary, hurts it very much if counterfeit. We must, however, observe that its effect upon counterfeit colours is not always the same, because they sometimes get a blue ground of woad or indigo. This ground being true cannot be removed; the red colour only is effaced, the darker shades becoming almost blue, and the paler, the disagreeable colour of wine lees.

XI. With regard to the violets—*half-fine*, prohibited by the present *Regulations*—they should be classed with the counterfeit violets, and are no more capable of withstanding these solvents.

XII. We may in the same manner easily distinguish the true *gris-de-lin* from the counterfeit, but the difference is trifling; the true loses rather less than that of the false.

XIII. True purples are perfectly proof against the alum solution; on the contrary, the false purple loses great part of its colour.

XIV. Lobster colours, etc., if obtained from cochineal, grow rather purplish by the proof-liquor; but fade considerably if obtained from fustic, which is prohibited.

XV. Blues, whether of woad or indigo, lose nothing by trial; but if false are almost entirely destroyed.

XVI. Slate colours, lavender greys, etc., lose almost all their colour, if false; but if true, stand perfectly.

XVII. The following colours are tried with a solution of soap, viz.: orange and all yellow shades, all kinds of green, madder reds, cinnamon, tobacco, and such like colours.

XVIII. By this solution we are perfectly instructed concerning the goodness of yellows, for it almost entirely destroys the colour if obtained from any of the prohibited ingredients.

XIX. By this solution also we are thoroughly informed concerning the quality of greens; as false green is almost entirely bereft of colour, or becomes blue if it has had a ground of indigo or woad; but if true, it loses no part of its green shade.

XX. The reds of madder are only the brighter for the soap solution, unless Brazil wood be mixed with the madder, and then they lose colour in proportion to the quantity of the Brazil.

XXI. Cinnamon colour, etc., are scarce altered by this solution, if true; but if obtained from fustic, roucou, or flock, are much discharged.

XXII. The solution of alum can be of no use, and may cause many mistakes with regard to colours of the second class; for it neither hurts the fustic nor roucou, which are

nevertheless faded by the air, and discharges a great part of the savory and dyer's wood, which notwithstanding produce very good yellows and greens.

XXIII. The numerous shades of fawn or root colours, which comprehend all those not derived from the five primitive colours, are tried with a solution of red tartar. These colours are produced from the walnut husk, root, and bark, sumach, santal, and soot.

XXIV. The ingredients enumerated in the preceding article are genuine, except santal and soot, which, when the quantity is over much, hardens the wool. Hence all that can be learnt from the solution concerning these colours, is whether they are overloaded with santal or soot, in which case they lose considerably by the solution of tartar; but if obtained from the other ingredients, or with a moderate quantity of the two last, they withstand trial much better.

XXV. Black being the only colour that cannot be comprised in either of the three classes above mentioned, because it requires a much more active solution in order to discover whether the wool has had a basis of turkey blue, conformable to the *Regulations*, the solution is made in the following manner:—

An ounce of Roman alum powdered, and the same quantity of red tartar, is put into a pint of water and boiled; let it boil for a quarter of an hour. You then put in the pattern, and you wash it afterwards in fresh water; you will then easily discover whether it has had a proper basis of blue, in which case the wool will remain blue, almost black; but if not, it will become very grey.

XXVI. As it is sometimes the custom to brown some colours with nutgalls and copperas, and as this operation may have a peculiar effect in the trial, you will observe that though after the trial the liquor may appear loaded with colour, the

wool, if it has preserved its basis, is nevertheless well dyed; but if, on the contrary, it has lost its ground colour, it may be declared false.

XXVII. Though the browning liquor made with nutgalls and copperas be allowed, yet as it hardens the wool it were better to give the preference as much as possible to an indigo or woad vat.

XXVIII. Common greys produced with galls and copperas require no trial, because these colours are genuine, as they cannot be obtained other ways; but it is necessary that they should be first galled, and afterwards dipped in a solution of copperas, but less hot than that of galls, because by this means they are much more beautiful and fixed.

END OF PART I

PART II

THE ART OF DYEING SILK

SILK, as it is taken from the pods, is gummed by a kind of natural varnish, which makes it stiff and hard. It is also, at least in this country, of an orange colour, generally very dark. This stiffness is improper in the fabrication of most silk stuff, and its natural shade unfavourable to almost all other colours.

The first operation, therefore, in the art of dyeing silk is to deprive it both of its natural colour and varnish; but this, as it is easy to conceive, can only be accomplished by means of a dissolvent sufficiently powerful. Artists formerly employed in this process had certainly no great choice of solvents; the substance of this varnish is of a singular nature, and can only be encountered by one species of solvents.

This substance absolutely resists water; spirituous *menstrua*, particularly spirit of wine, so far from destroying the colour, on the contrary fix it more firmly. Acids, when sufficiently diluted to prevent them from destroying the silk itself, act but very imperfectly; in short, it is evident that nothing but alkaline salt will dissolve this gluten effectually, when sufficiently diluted and softened so as not to injure the silk.

The various properties of this substance demonstrate that it is neither gum nor properly resin, nor even gum-resin, and that it essentially differs from these substances. All

gums dissolve in water, resins in spirit of wine, and gum-resins in a mixture of both. It is therefore probable one of these concrete oily substances differs from resins in its only particles not being of the essential kind, but rather of that sweet kind, which, having nothing volatile, cannot be affected by spirit of wine. It is also probable that this gluten may consist both of an oily and gummy substance, but so proportioned and combined as mutually to resist their proper dissolvents.

Be this as it may, you can only succeed in depriving silk of its natural varnish by means of an alkaline salt, and this deprivation is called dressing. But whether they have not yet thought of employing for this purpose pure alkalies only, or whether they have found it rather inconvenient, in this country they are all evidently agreed in the use of alkalies softened by oil, that is to say, soap.

This ungumming of the silk, or boiling as it is called, is generally done by hot water impregnated with soap; but the particulars of this operation and the quantity of soap vary, as we shall presently observe, according to the purpose for which the silk is intended.

Silks intended for the greater degree of white, such for example as are meant to remain white, or for the fabrication of white stuffs, are boiled twice over; but all that are afterwards to be dyed of a different colour should boil but once, and with a smaller quantity of soap, because the little remaining redness is by no means prejudicial to many colours. Different quantities of soap are nevertheless necessary, according to the colour for which the silk is designed; but I shall speak more particularly concerning these quantities when I come to the article of dyeing. I shall now mention the method of boiling such silks as are meant for the greatest degree of whiteness, which, as I said before, should be twice boiled.

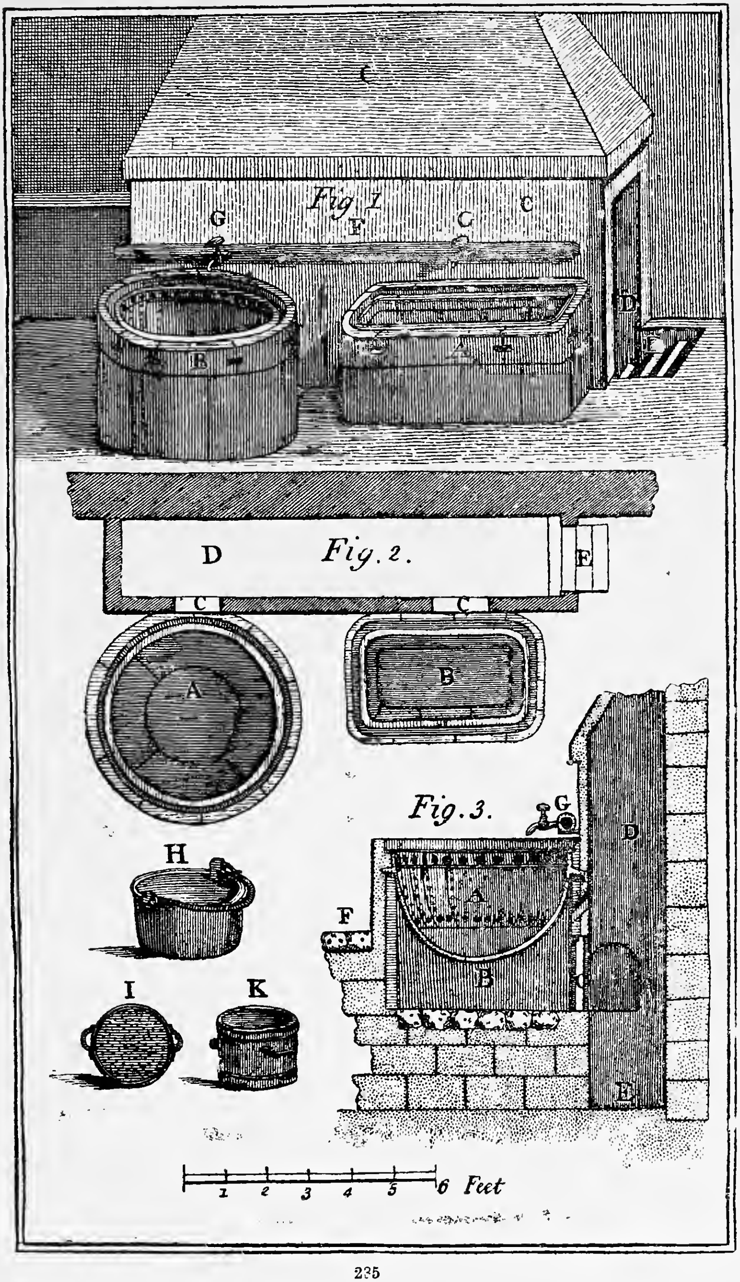
Fig. 1
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C
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B
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F
Fig. 2.
D
E
C
C
A
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Fig. 3.
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H
I
K
1 2 3 4 5 6 Feet

Ungumming and Boiling for White

The first boiling for silk intended for white is called ungumming, because the end proposed in this operation is in effect to deprive the silk of a large portion of its gum.

To accomplish this ungumming the silk is first divided into hanks; that is to say, by tying a thread round each hank, consisting of several skeins. These hanks are afterwards untied, and several of them joined together, making a handful varying in size according to the different manufactories. At Lyons this handful is called a *matteau*; at Tours, a *parceau*; and at Paris, a *bouin*; and it has still a greater variety of names in different places.

This precaution with regard to the silk is very necessary, as it facilitates the dressing, makes the working of it less difficult, and prevents it from mixing and tangling.

After this operation a sufficient quantity of river water is put into an oval copper, as in Plate I. Fig. 1, or any other water proper for dissolving the soap. About thirty pounds to one hundredweight of silk. The soap is cut into small bits, that it may dissolve more readily.

When the soap is dissolved by boiling, the copper is filled with fresh water, and the door of the furnace shut, only leaving fire sufficient to keep the liquor very hot, but not boiling, for the boiling would open and fuzz the silk, particularly fine silk.

Whilst preparing the liquor the silk is passed on to the rods, and when in a proper state is put into the liquor, where it remains till the part dipped is deprived of its gluten, which is soon perceived by its whiteness and flexibility. It is then turned round on the rods, that the part above the liquor may undergo the same operation; and as the solution is accom-

plished the silks are taken out of the liquor, the hanks that were first turned being always the soonest done.

The silk thus ungummed is put on the pegs to drain it of the soap, and then dressed; that is to say, worked on the pegs and in the hands that it may be opened and disentangled.

A cord is then passed through the hanks in order to confine it during the boiling; and this is called cording.

Nine or ten hanks are put on each cord (as in A, Plate III. Fig. 2). It is then put into a bag or pocket made of coarse, strong linen. These pockets are fourteen or fifteen inches wide, and four or five feet long, closed at each end. They are open at the side the whole length of the pocket, and when the silk is put in, the pocket is sewed all along down the side with packthread, and fastened with a knot.

Five-and-twenty or thirty pounds of silk is put into each pocket. This operation is called pocketing, as in F, Plate II. Fig. 1.

This done, another liquor is prepared like the first, viz. the same quantity of soap for a hundredweight of silk. When the soap is well dissolved, and the boiling checked with cold water, the pockets are put into the liquor and boiled hard for about a quarter of an hour, checking with cold water whenever it seems ready to boil over. During this boiling it is necessary to *barr* often, that is by means of a barr or pole (as in C, Plate II. Fig. 2), to move the bags one over the other, so as that the undermost be brought to the top of the liquor to prevent them from sticking to the bottom of the boiler. This motion is also requisite to make them boil equally and even more readily.

The preceding operation is called boiling; is used for silks intended to remain white, and is done in a round boiler (B, Plate I. Fig. 1).

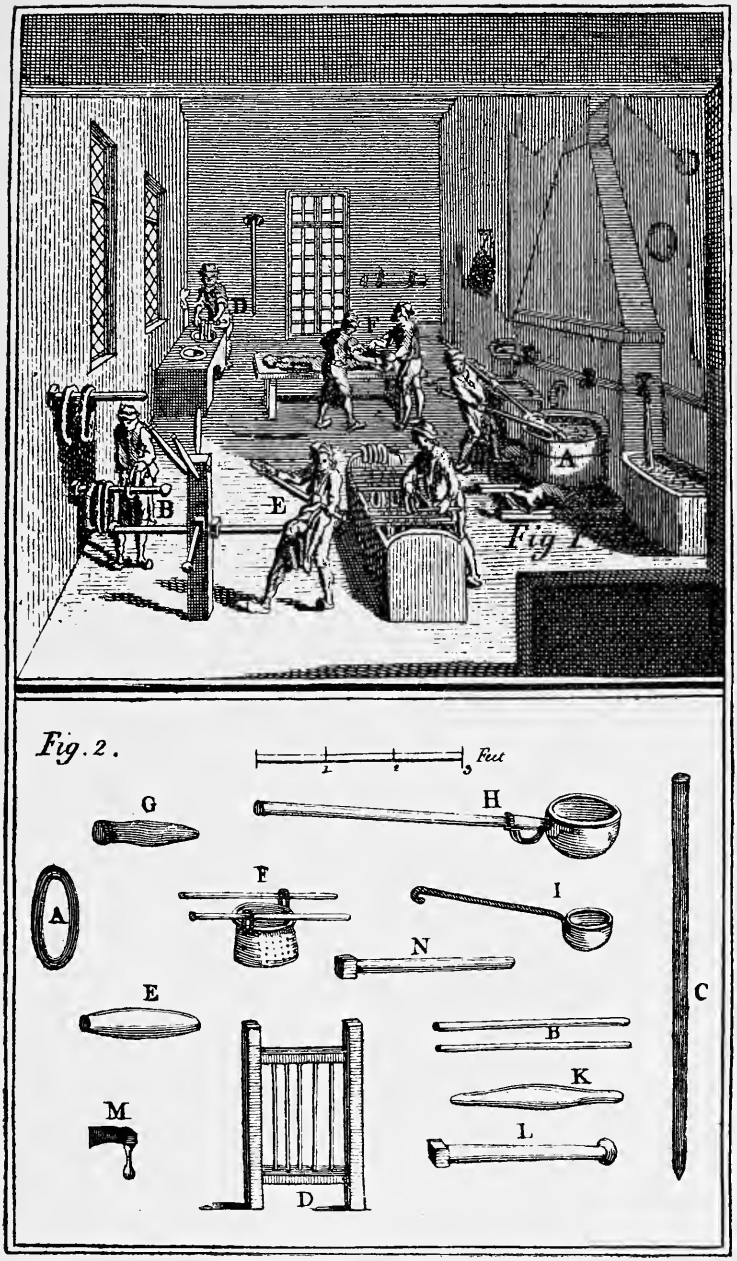
Fig 1.
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Fig. 2.
Feet
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For Boiling of Silks intended to be Dyed

In the boiling of silk for common colours, twenty pounds of soap is required for every hundred pounds of raw silk, and the boiling is then the same as in the preceding operation, with this difference only, that as the silk is not ungummed it should boil for three hours and a half, preserving a sufficient quantity of liquor by carefully filling it every now and then with water.

Silk designed for blue, iron-grey, brimstone, or any other colour requiring a very white ground, and to be as beautiful as possible, must have thirty pounds of soap to every hundred of silk, because they should be quite as clear as if they were to remain white.

When the silks are boiled they are cast down; that is, the pockets taken out of the boiler. For this operation there must be a rod or perch smaller than that already mentioned. This small perch is slipped under the pocket, resting it on the edge of the boiler, by which means the bag is raised up.

A perch or rod long enough to reach from side to side of the boiler is then passed under, and rolling under the bag successively, passing it from one perch to the other till entirely out of the liquor, when it is immediately thrown on the ground. It is very necessary that the place where the pockets are thrown should be perfectly clean, or even covered with linen or planks, to prevent any dirt from penetrating the bags and making spots; or it were still better to throw it on a *baillard* or barrow (see D, Plate II. Fig. 2, and the operation A in the same plate, Fig. 1).

When put on the barrow the pockets are unsewed by untying the knot and drawing out the packthread. The silk is then taken out and examined, and if not sufficiently boiled,

or double boiled, as the dyers improperly call it, which is easily seen by the yellow or lemon colour spots still remaining, it is returned into the copper, where it is again boiled for some time till it is evidently well done. It is then taken out, and the pockets thrown down as at first.

After unpocketing, the whole is dressed on the pegs, as may be seen in B, Plate II. Fig. 1, in order to dispose the silk for taking the colour intended.

Observations on Ungumming and Boiling

For the boiling of silk it is necessary to use the best Marseilles white soap, soap of an inferior quality not being equally effectual; besides, in using such soap there is nothing saved, as a greater quantity is required. There is a kind of soap which, coagulating with the natural varnish of the silk, forms a substance like wax.

Fat soaps are sometimes used for boiling of the silk; but it is evident that silk boiled with this soap is never so dry nor so lively as it ought to be; besides, it reddens in course of time.

Silk usually loses a quarter of its weight in boiling; some even 2 or 3 per cent. more.

The soap liquor used in the boiling of silk very soon putrefies and gets a bad smell; it is then good for nothing. If the silk is heaped when warm out of the soap, for any time without being washed and cleansed, it heats, gets a bad smell, and even produces little white worms. These worms, however, do not eat the silk, only the mixture of the soap and gluten. This silk is liable to be hard.

Silk that has not been boiled, or raw silk, is always hard and stiff; hence the absolute necessity of boiling, not only to deprive it of those bad qualities, but to discharge the yellow colour natural to most kinds of silk. Pure water

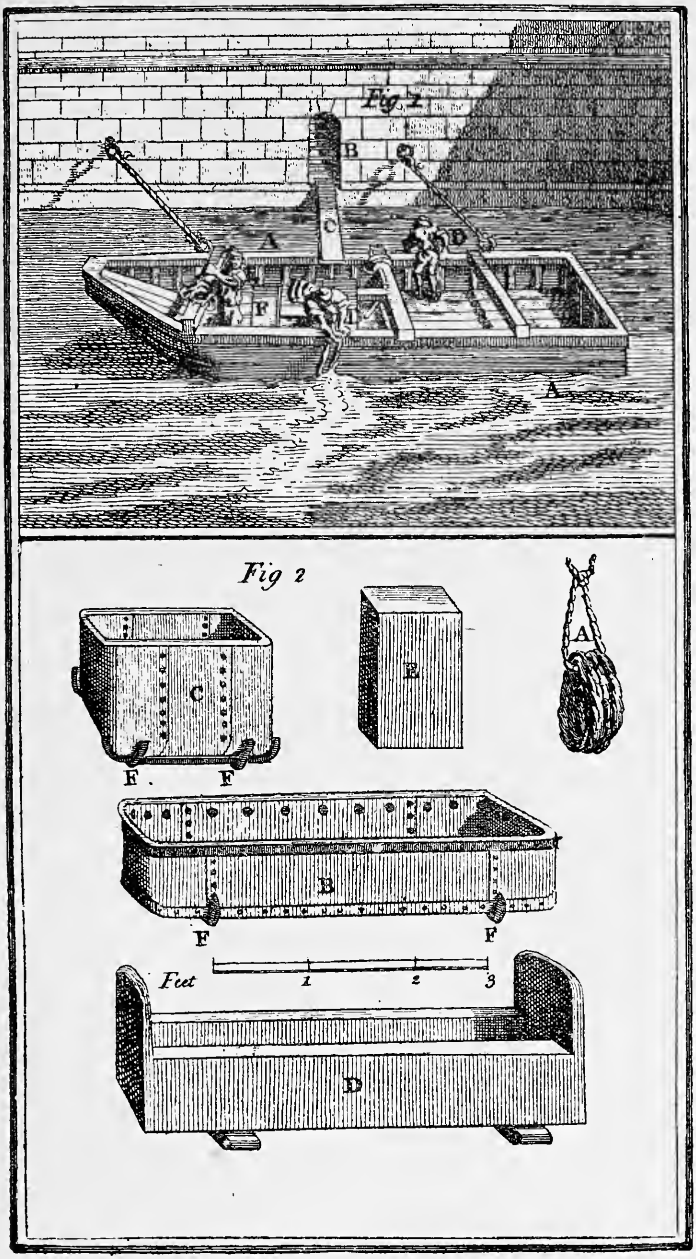
Fig 1
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Fig 2
C
F. F
E
A
B
F F
Feet 1 2 3
D

should be used for this purpose capable of dissolving the soap.

When river water is muddy it should be left to subside for some time, and then put into a boiler and purified in the following manner:—

When it is made hot, without boiling, about a pound of soap to thirty buckets of water is thrown into it. This soap raises all the impurities to the top of the water like scum, and this being taken off with a skimmer the water is fit for use.

These are the methods that have been hitherto used in all the manufactories of Europe for boiling and preparing silk. They may, however, be changed, at least in some particulars, as the principal merchants and manufactories of silk stuffs have for some time past remarked that the stuffs of this country, which are prepared with soap, have several and singular defects, and less lustre than the silks of China, which are, they say, prepared without soap. These considerations induced the Academy at Lyons to propose, as a subject for the year 1761, a method of preparing silk without soap, and the premium has been lately decreed to M. Rigaut, of St. Quintin, already known for several chemical inquiries very useful both for the improvement of the arts and with respect to commerce.

This philosopher, prepossessed by an edict of the academy that the oil in the soap produced the bad qualities so much complained of, proposed as a substitute for soap a solution of soda in a proper quantity of water, so as not to impair or weaken the silk, which doubtless answered the expectations of the academy.

Of White

Silk when deprived of its gum and boiled as we have said, acquires by these operations the greatest possible degree of

whiteness; but as there are different shades of white, some with a yellow cast, some blue, and others reddish, the dyers are obliged when they would obtain any particular white, to add some ingredient either in the softening, the boiling, or by a third liquor slightly impregnated with soap, called the whitener. I shall now describe the method of giving silk the principal shades of white.

Whites are distinguished by five shades, or rather five principal shades, viz. China white, India white, thread or milk white, silver, and azure white. All these whites, though differing from each other by very slight shades, are nevertheless apparent, especially when compared with each other.

The three first whites are prepared and boiled as I have already shown.

The silver and azure white require azure in the preparation or ungumming of the silk, which is done in the following manner:—

Take fine indigo, wash it two or three times in clean water moderately warm, pound it afterwards in a mortar, and pour some boiling water on it. It should then stand till all the gross particles of the indigo fall to the bottom; the clear only should be used, which is called azuring.

This azure is put into the soap liquor for ungumming of the silk.

The quantity of the azure is not specified, because if the silk appears deficient more may be added to the whitening.

For silver and azure white, the boiling should be azured according to the eye, as for ungumming.

When boiled, the silk is taken out of the copper by *barring*, that is, by means of a small bar, as already explained; but instead of throwing the pockets on the ground they are put in a barque, or trough full of clean water. The pockets are opened in the water and then taken out, but the silk remains.

It is then spread and opened in the water; it is afterwards washed and laid on the barrow, which is placed across the trough, and through which the silk is drained.

The first soap and water is again put into the copper in which the whitening was boiled, and which serves for another boiling.

The trough is again filled with clean water, in which the white shades are washed and rinsed; they are then drained, and afterwards dressed. The silks are then made into hanks proper to be wrung, and at the same time the whitener is prepared in the following manner:—

Whitening

To make this, the copper must be filled with clean water, and a pound or a pound and a half of soap added to thirty buckets of water. When it boils and the soap is dissolved, it should be well struck with a staff, to see if the whitening be more than sufficiently strong, or not strong enough. Either of these inconveniences should be equally avoided, for if it be too poor the silk will not be uniform, and if too strong it will not take the azure properly, but will be spotted blue in several parts. The whitening is good if, when striking it with a stick, the froth it produces is neither strong nor weak. The silk is then put on the rods and dipped as follows:—

For China white, examine the liquor, adding for a reddish tinge a little roucou, and proceed as follows:—The hanks being all ranged on the rods, should be plunged into the liquor, and these rods reaching from side to side of the vessel, are so placed that the hanks hang perpendicular, falling into the liquor, except the upper part, which being on the rods, and the vessel not being quite full, remain out. The rods are afterwards taken out one after another, turning the silk upside down

that every part may be equally dipped, at the same time pushing the rods to the extremity of the vessel. This operation is repeated till the silk is sufficiently and uniformly tinged, and is called returning. At first it should be repeated without intermission, and till the shade is uniform; but at last, when the liquor becomes weaker, the dipping should be less frequent (see this operation in C, Plate II. Fig. 1).

For India white the process is the same, only adding a little azure for the blue cast, not to spoil the whitening which is intended for other whites.

For thread-white and others, a little azure is added in proportion to the shade required.

The liquor should be very hot, but not boiling, during the operation, and the returning continued till the silk has taken the shade equally, which it generally does in about four or five returns. The silk as it becomes even and finished is wrung, and afterwards spread on the poles to dry, and then, if necessary, sulphured, which is done in the following manner:—

Sulphuring

White silk intended for any kind of manufacture, except such as are to be watered, should be sulphured; the acid of sulphur giving the greatest possible degree of whiteness. It is done as follows:—

The hanks should be shred on perches seven or eight feet from the ground, choosing for this purpose a high room without a chimney, or an elevated barn, where, in case of necessity, you may procure access of air by throwing open doors and windows.

A pound and a half, or two pounds of sulphur in rolls, will sulphur a hundred pounds of silk. This brimstone should be put into an earthen or iron pot with a few ashes at

the bottom. When grossly pounded it is put on the ashes; you then light one of the bits with a candle, which will set fire to the rest.

The chamber should be close shut, and the chimney carefully stopped to prevent the vapour from dissipating. The sulphur should burn under the silk during the night.

The next morning the windows should be opened to let out the smoke and admit the air, which in summer is sufficient to dry the silk.

But in winter, as soon as the smoke is dissipated, the windows should be again shut, and fire put into the chaffing dishes to dry the silk. It is of great consequence that the place for sulphuring should be so situated that the windows and doors should open at the outside, and remain open till there is a free circulation of air, as without such precaution there would be some danger of suffocation.

When the sulphur is consumed it leaves a black crust. This crust being extremely combustible, serves afterwards to light the sulphur, as it takes fire even more readily than the sulphur itself before it is burnt.

If, in dressing, the silk sticks together, it is not yet sufficiently dry.

Observations on Whitening and Sulphuring

The sulphurous or vitriolic acid which flies off in great quantity during the slow combustion of the sulphur, having the property of eating and destroying the generality of colours, acts upon the silk in such a manner as to make the whites perfectly clear and transparent. It destroys the remaining yellowness, which mixing with the azure would give it a greenish cast. It likewise gives the silk more firmness, and even that rustling called by the French *cri*, or *maniement*.

This is very perceptible when by rolling the threads of a skein upon each other and pressing them hard with the finger, a kind of vibration or rustling is communicated to the hand, and may be even heard by putting the ear close and being attentive.

As this rustling proceeds from the hardness or stiffness of the silk, it is not the custom to sulphur such as are intended for goods that are to be watered, because when sulphured they do not take the impression sufficiently, as it prevents the threads from rolling freely over each other so as to take a good water.

To avoid the inconvenience resulting from this hardness, it is the custom in some manufactories to take out the sulphuring, which is done by dipping them several times in hot water on the rods as for dying. This operation renders the silk softer and destroys the rustling, but then it is always less proper for being watered than if it had never been sulphured. If the silk that has been sulphured is to be dyed, it should be unsulphured, there being several colours that will not take well without this precaution.

If when the silk is sulphured it is apparently not sufficiently azured for the shade to which it properly belongs, it must be again azured with clean water, only without any soap; but it is necessary to observe that if for this purpose the hard well water be used, it will make the azure much more blue than soft water, which, on the contrary, gives a reddish tinge.

Silk thus azured should be a second time sulphured. The first sulphuring, however, is not entirely useless, as the acid of the sulphur facilitates the azuring with water only, but would not have the same effect with soap.

With regard to the boiling, in want of azure you may add a little of the indigo vat prepared for dyeing blue, as we shall hereafter mention, called by the dyers the *blue of the vat*. It

will have the same effect provided it be taken from a vat in full strength. In case of necessity this blue may be used for azuring with water. It is, however, liable to give a shade less beautiful, because a small quantity of this preparation mixed with much water loses its quality and becomes grey.

Some stuffs are always fabricated with raw silk, containing all their natural gum and stiffness, requiring in themselves to be firm and gummed, such as silk laces, known in trade by the name of blonds, gauzes, and the like. Silk intended for this manufacture should neither be ungummed or boiled; it is therefore to be observed that in giving them the various preparations necessary for dyeing, these preliminary operations are to be omitted. For this reason it is also necessary that at the end of every process you should be particularly attentive in marking the best methods for making raw silk take the various colours. I shall now speak concerning the raw and white silk used in the species of manufacture above mentioned.

Those naturally the whitest are the best. They should be dipped in warm water and wrung; then sulphured; afterwards azured, again wrung, and a second time sulphured: this at least is the common practice. Experience, however, shows that it may answer just as well to soak it in the soap liquor, as for whitening, and only hot enough to bear it to the hand. In this liquor the silk is returned, adding azure if necessary. When sufficiently done it should be well washed at the river, which restores the firmness it had lost in the soap water. It is then wrung and sulphured.

It must be observed that this method of whitening raw silk is used for those of an inferior quality; the fine silk of Nankeen, which is of a nature extremely white, requiring no such operation.

Of Aluming

Aluming should be considered as one of the most general operations in the art of dyeing. It acts as an astringent, without which the greatest part of the colours would never adhere, or at least would have neither beauty nor solidity. This salt unites two admirable properties, and of the greatest importance in the art of dyeing; that of augmenting the brightness of an infinity of colours, and at the same time of fixing them in the most solid and durable manner.

Alum is always used in dyeing of wool, cotton thread, and silk; but the manner of application is different. The following is the method for silk, which is the object of this treatise:—

Forty or fifty pounds of Roman alum being dissolved in a copper, with a sufficient quantity of hot water, is put into a large tub or tun containing forty or fifty buckets of water (see B, Plate IV.). When pouring the solution into the vessel, stir and mix it well, lest the cold water should crystallise and coagulate the alum, in which case the silk would be spotted in various places with small crystal spots, called by the dyers frosting. Whenever this happens, by dipping in warm water the crystals are immediately dissolved, and the water may be added to the alum tub.

Having washed the silk, it is beetled, and the better to clear it from any remaining soap, drain it on the pegs and tie it in hanks as for boiling; the hanks are then dipped in the alum liquor one after another, taking care to prevent them from tangling and twisting together. They should be loosely tied, that every thread may be equally dipped. In this situation it should remain eight or nine hours, generally from night to morning. After this it is taken out, and when wrung with

the hand over the tub, carried to the river and rinsed, which is called cooling; then beetled as long as it is necessary. But of this in its proper place.

In some manufactories, instead of tying the silk for the aluming, it is passed on the rods, three or four hanks upon each rod, giving them three or four shifts or returns. They are then entirely dipped, plunging every rod by the end that is loaded with the silk, the other end supported on the edge of the trough. The dyers call this putting in *soude* or soak, meaning in general by this expression, the submersion of the silk into any liquor whatsoever, where they are suffered to remain for any time.

To prevent the silk from slipping off the rods and mixing together, care should be take to have a perch just the length of the trough, upon the edge of which the ends of the rods are supported in such a manner as to hinder the silk from slipping off. A cord tied to the end of the first and last rod, going under the ends of every other, will answer the same purpose as the perch.

When the alum liquor is prepared as above described, a hundred and fifty pounds of silk may be dipped without any necessity of adding fresh alum, or according to the terms of the art, refreshing.

When the liquor apparently begins to weaken, which is soon learnt from practice, being less sharp to the taste, twenty or five-and-twenty pounds of alum dissolved as before, should be added to the liquor, with the same precaution as above, thus continually replenishing according to necessity and till the liquor begins to have a bad smell, which is always the case sooner or later in proportion to the quantity of silk that has been dipped.

When the liquor begins to be offensive, you finish, by dipping those silks intended for ordinary colours, such as browns,

maroons, etc., and afterwards throw away. The trough is then rinsed and prepared for a fresh liquor.

Remarks on Aluming

When a trough of aluming has been used for some time, it forms all round on the side an incrustation, frequently as thick as a crown piece, not so much on the bottom as at the sides, because the silk often touches the bottom of the trough, and by sweeping it in a manner prevents the formation of this crust.

The dyers leave this incrustation, having remarked that so far from producing any bad effect it helps to retain the liquor, and prevents the vessel from leaking. This crust is occasioned by the silk being commonly put into this liquor without being entirely deprived of the soap, which, mixing with the alum, they mutually decompose each other. The acid of the alum, and the alkali of the soap, form a vitriolated tartar; at the same time the earth of the alum with the oil of the soap forms a thick substance, and these together produce this incrustation.

It is also very evident that to this portion of soap generally remaining in the silk when put into the aluming, may be attributed the bad smell of the liquor when used for any time.

The silk should always be alumed cold, because it has been found that if the aluming be warm the silk is apt to lose a great part of its lustre.

We know by experience that it is always more advantageous to make this liquor rather strong than weak, as the silk with more certainty takes the colour; whereas if too weak, it not only takes the colour with more difficulty, but is likewise uneven.

Of Blue

Silk is dyed blue with indigo, like all other substances capable of being dyed ; this drug however is of a very particular nature, for the colouring substance being resinous, it imparts no colour to the water, in which it will not dissolve. It must therefore be dissolved by some saline substance, by a kind of fermentation. But as this species of dyeing requires a particular operation, and vessels of a singular nature and convenient structure, called vats, I will endeavour to describe them, as also the method of preparing the indigo, particularly for dyeing silk.

These vessels are generally made of copper, in the form of a truncated cone, or like an inverted sugar-loaf (Plate IV. Figs. 1 and 2). The under part or bottom (C) about a foot in diameter, and the upper part about two feet. It is four and a half or five feet in height. The bottom fixed in the ground, about a foot and a half deep, as in D, Fig. 1. It is surrounded with a paved hearth (E, Fig. 2), and enclosed with masonry (F, Figs. 1 and 2), perpendicular, not joining to the vat, but in such a manner as to leave a space round the vessel (G, Fig. 2) larger at the bottom than at the top. It joins, however, at the top, forming a kind of flat border (H, Fig. 1) of about six or eight inches.

It is customary to have two openings in this masonry, one upon a level with the ground (I, Fig. 1), about a foot in length and six or seven inches broad, where the fire is put in.

The second opening is formed by a funnel of freestone or plaster, a kind of chimney (L, Figs. 1 and 2), for the purpose of supporting the fire by a current of air. This funnel should rise about eighteen inches above the vat, to prevent the workmen round it from being incommoded with the smoke or

vapour. So far with regard to the construction of the vessel; I shall now speak of the indigo preparation.

To begin with the *brevet* or composition, as it is called: it is made in the following manner:—

To eight pounds of the finest indigo add six pounds of the best pearl ash, from three to four ounces of madder for every pound of ashes, besides eight pounds of bran, washed in several waters to take out the flour. When washed and most of the water squeezed out, it is put alone at the bottom of the vat.

The pearl ash and the madder are then mixed, bruising them roughly together, and then boiling them for a quarter of an hour in a copper containing two-thirds of the vat; the liquor is then suffered to rest, and the door of the furnace shut.

Two or three days previous to this, eight pounds of indigo are steeped in a bucket of warm water, washing it well, and even changing the water, which has a reddish cast. Some dyers begin by boiling the indigo in a ley consisting of one pound of pearl ash and two buckets of water. They afterwards pound it in a mortar quite wet, and when it is pasty, fill the mortar with the liquor before boiled and still hot, bruising it for some time, letting it stand a few moments, and then pouring off the clear into a separate boiler or into the vat. The same quantity of the mixture is then poured on the indigo which remained in the mortar, bruising and mixing it well, and then, as before, pouring off the clear into the boiler; and this is repeated till the whole of the indigo is thus dissolved in the liquor.

The liquor in the boiler is gradually poured into the vat on the bran at the bottom, adding afterwards the remainder of the composition, grounds and all. After stirring and raking for some time, it is let stand, but without fire, till it becomes cool enough to bear the hand in it, when a little fire is put

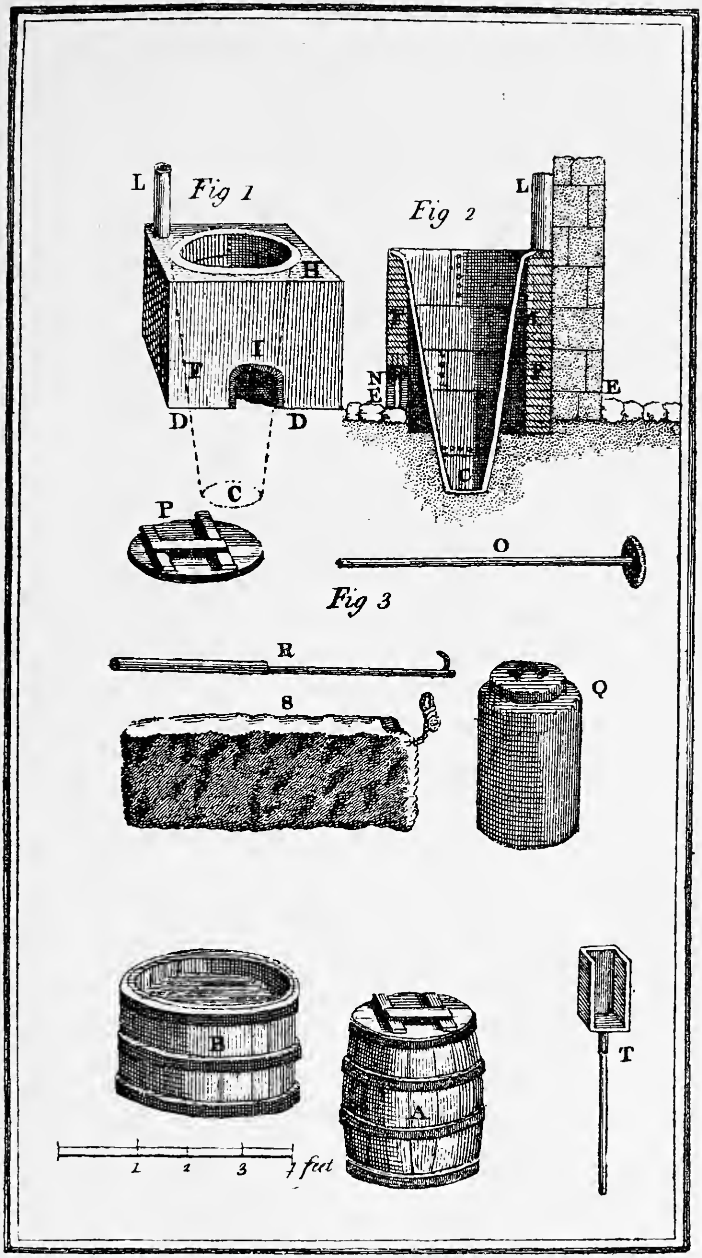
Fig 1
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round the vat, only to preserve the same degree of heat. This should be continued till the liquor begins to turn green, which is easily known by trying it with a little white silk.

The vat in this state indicates that she is coming to; that is to say, that the operation goes on well; but for better information, and in order to bring it forward, it should be struck with the rake, and then suffered to stand, till the brown and coppery scum that rises on the surface shows that the vat is come to.

But as it is necessary to be very certain of this, the scum should be well examined, and if when blown aside it immediately forms a fresh scum. In this case it is suffered to stand for three or four hours, and then a new composition is made in order to complete it. For this purpose as much water as is requisite to fill the vat is put into a copper, boiling it with two pounds of ashes and four ounces of madder as at first. This new liquor is poured into the vat, raked, and mixed, and then left to stand for four hours, when it is ready for dyeing.

Silk for the blue dye should be previously boiled in about thirty-five or forty pounds of soap to about every hundred pounds of silk, but not impregnated with alum, because the colouring particles of indigo, and indeed of all resinous substances, want no astringents to make them adhere.

Before the silk is dipped in the vat it should be previously washed from the soap, and to discharge it more effectually, twice beetled at the river, having been divided into hanks for the conveniency of wringing. One of the hanks is passed on a round staff fourteen inches long and an inch and a half diameter, called a *passe* (see E, Plate II. Fig. 2), then plunged into the vat, giving it some returns, sufficient to produce the colour you would have, and to make it even.

It is then wrung as hard as possible with the hand over

the vat, not to waste the liquor, opening and spreading with the hand till it ungreens, when it should be immediately washed in two different waters provided in troughs within reach of the workmen. When washed it should be put on the end of the peg or wringer, and wrung as hard as possible (see this peg, E, Plate II. Fig. 1), and wiped with another skein sufficiently drained, to imbibe the liquor that is squeezed out by the wringer. It should have four turns as quick as possible in this manner, and then be wrung on the middle of the peg twelve times, that the water remaining in spots after the four turns may be equally distributed.

When wrung and drained sufficiently the silk should be spread on the rods, that it may dry as quick as possible, remembering if the hanks are large, to cut the thread by which they are tied, to prevent their reddening under the string, which frequently happens if kept tied. Every hank to be dyed should be successively managed in the same manner.

Remarks on the Blue of Indigo

Silk dyers seldom use any other vat than what I have above described; there, is however, another that may be usefully employed, especially for greens. It is made like the preceding, with this difference only, that half a pound of madder is added for every pound of pearl ashes. This vat is much greener than the first, and gives the silk a more permanent colour, and at the same time no less pleasing to the eye. When exhausted of its colour it becomes brown, almost the colour of beer; whilst, on the contrary, the preceding vat becomes blackish.

With regard to other vats, viz. those made with urine, whether cold or hot, and such as are cold, made without copperas and without urine, they are no more used than the pastel

or woad. These kind of vats are too tedious, and, besides, some of them make the silk hard.

The vessel used for the indigo vat is generally of copper. I have already observed, nevertheless, it may be made of wood, but for this purpose the staves should be an inch thick, of a proper height, and bound with iron hoops. The bottom, however, should not be made of wood, because by the heat it would be apt to warp and to rot from the moisture of the ground. Instead of wood therefore the bottom should be made of lime and cement, put into the vat as it stands on the ground, about six inches high. While the mortar is fresh it should be levelled with a trowel, and as it dries, the cracks and opens carefully stopped. This mortar is commonly made without more water than was used for slaking the lime.

This vat cannot be used till the mortar is perfectly dry. For the purpose of emptying this vat, it is usual to make an opening of about eight or ten inches at one side, upon a level with the ground, covering it with a plate of copper, and taking care to fix it three or four inches below the ground, nailing it close to prevent the liquor from ousing out. It is usual to make the hearth opposite to this plate with the funnel or chimney, the same as for the copper vat. But as this vat is liable to open and disunite in consequence of the pearl ashes, which produce the same effect on wooden buckets, the copper vats are always most advisable.

The indigo commonly used by the silk dyers is called copper indigo, because of the copper colour on its surface, and even interiorly; nevertheless, several other kinds may be used with equal profit superior to this, such as the blue indigo, which is lighter, finer, and more pure than the copper indigo; also Cadiz indigo, or the indigo of Guatemala, the finest and best of all. But the price of those, particularly the last, prevents them from being used.

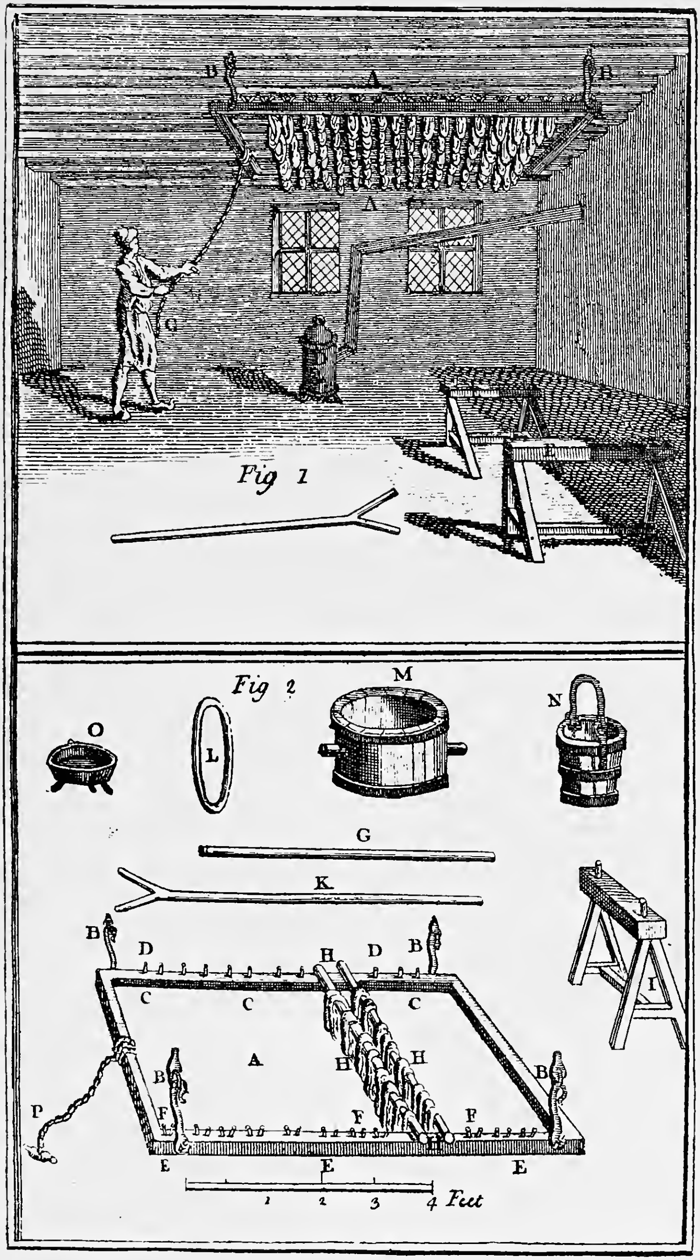
Madder is generally added because it is supposed to improve the blue.

All silk dyers wash the flour out of the bran, that it may not be too glutinous; the bran is, however, useful for greening and working the indigo. We must observe that the greater the quantity of bran, the better the vat, and therefore I have prescribed more than is generally used in this process. When the vat subsides it should be then raked, as I have already said, and stirred no more, unless it should begin to green; for it is observed that the necessary fermentation is retarded by the raking.

Silk dyed in the blue vat is apt to take the colour very unequally, which it does most certainly if not washed and dried immediately after dyeing; hence the necessity of dipping the silk in small parcels, of washing directly, of wringing it well, of drying instantly, and opening it well. Fine dry weather is always the best for these operations, for should water fall on it even accidentally whilst drying, it would be full of reddish spots. It is therefore necessary in moist weather and during the winter to dry in a room with a stove, continually shaking the rods on which the silk hangs (see Plate V. Fig. 1).

For this purpose it is necessary to have a kind of frame (see Plate V. Figs. 1 and 2), viz. an oblong square formed of four pieces of wood, two of them ten or twelve feet, and the other two, six or seven feet, suspended from the ceiling with movable iron cramps (B, Figs. 1 and 2), in such a manner that the frame may be easily moved backward and forward. On one of the two sides (C, Fig. 2) there are a number of iron spikes (D) three inches long, and placed four or five inches asunder. The other long side (E) has opposite to every spike a fork (F).

When about to dry the silk, it should be put on rods, one end of which, having a hole, goes on the spike, whilst the other end rests on the fork, by which means the rods are prevented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from falling when the shaker is moved. As the hanks are wrung they should be spread on one of these cross rods, continually shaking, till every part of the silk is successively arranged and dried.

In order to produce different shades of blue, the silk intended for the darkest should be first dipped in the fresh vat, and so on, continuing to dip in the same manner; only as the vat weakens, the silk should be kept in a little longer each time, till the vat is so much exhausted that even after two or three minutes, or more, the shade appears still weaker. The vat when thus exhausted serves for the lighter shades, even to the lightest.

It must be observed that having thus dyed a quantity of silk, the vat generally tires, that is, loses its green, giving a colour less beautiful. In this case it is necessary to feed the vat with a fresh composition or *brevet*, as follows:—A decoction of one pound of pearl ash, two ounces of madder, and a handful of bran boiled together for eight minutes either in water or in a portion of the same vat, if she is yet sufficiently full to afford it. After this mixture is added, it should be well raked, and suffered to rest for two or three hours, more or less, before the dyeing is again resumed.

For the finest blues a fresh vat is the best, and therefore if only pale blues are required, to make a vat with a small quantity of indigo would answer better than a strong vat that has been weakened. Light blues done in this manner are much more lively; the dyers, however, seldom attend to this circumstance, for the price for dyeing blue being very moderate, it is not worth their while.

A blue vat, according to the size of the vessel described, will take from one to eight pounds of indigo; this quantity, however, may be exceeded by some pounds, without inconvenience.

Silk dyers distinguish only five different blues, viz. light blue or porcelain blue, sky blue, middle blue, king's blue, and Turkish or complete blue. These have their intermediate shades to number, but no particular names.

Deep blues cannot be made by the vat only, because the indigo never gives a colour sufficiently full for these shades: hence it is necessary to strengthen the colour by previously giving them the archil, commonly called a footing or ground. Turkish blue, the deepest of all blues, should have a very strong archil liquor, prepared in the following manner. This ground, though not so strong, is also given to king's blue; but they should all of them be dipped in a fresh vat well supplied.

To give this archil liquor or ground, the silk when taken out of the boiling should be beetled at the river, and then hung to drain.

The silk is then dipped in the archil liquor whilst very hot, and returned till the colour becomes uniform. It should be afterwards washed and beetled, then dressed, and then dipped in the vat.

With regard to all other blues, they require no ground, only previous to their being dipped in the vat the silk should be carefully cleansed from the soap after boiling and twice beetled, else the soap leaves a white sediment, which if in any quantity spoils the vat.

There is yet another blue as dark as king's blue, but the ground for this is made of cochineal instead of archil, for which reason it is also called fine blue. But as the dyeing with cochineal requires a particular process, we shall defer this colour to the article "Fine Violet."

King's blue, in imitation of blue cloth, is made in the following manner:—

One ounce of verdigris for every pound of silk is dissolved in a mortar or basin of cold water by means of a pestle, and

the silks, generally in hanks of about five or six ounces, returned in this liquor. They take a slight shade of verdigris, but so trifling as to be scarce perceptible when dry.

When sufficiently verdigrised, the silks should be wrung, then put on the rods and dipped in a cold logwood liquor, more or less strong according to the shade required. In this liquor it takes a blue, like the king's blue on cloth ; but the colour is very bad, flies off immediately, changing to an iron grey. To prevent this inconvenience and to make it more permanent, it should be taken paler from the logwood than the pattern to be matched, giving it a little warm archil, which reddens and rouses the browning. It should afterwards be dipped in the vat, when the colour will be much more durable.

When the silk is to be dyed raw, or without having been boiled, care should be taken to choose the whitest. It should be formed into hanks and soaked in water ; but to make the water penetrate more perfectly, it should be twice beetled. When soaked and dried, the hanks are dipped in the vat, like boiled silks, and then dried in the same manner.

Raw silk generally takes the dye sooner and better than boiled ; as much as possible therefore of the boiled should be dipped before the raw, the first requiring the whole strength of the vat. If the blue for the raw silk be a shade requiring archil, or any of the above-mentioned ingredients, it should be given in the same manner as to boiled silk.

Of Yellow

The boiling of silk intended for yellow should have about twenty pounds of soap for every hundred pounds of silk.

When boiled they should be washed, alumed, and again washed (which is called refreshing), dressed, and put on the

rods in hanks of about seven or eight ounces, and then dipped and returned in the yellow liquor.

To make fine yellow, or grain yellow, as the silk dyers call it, they seldom use any other ingredients besides weld.

For this purpose a copper is prepared with about two pounds of weld to every pound of silk, and that all the weld may be well soaked it is loaded with a large piece of wood. When it has boiled a good quarter of an hour the bunches are pushed to the far end of the copper, or rather, if you please, taken out; and by means of a bucket or ladle all the liquor may be taken out of the copper, and strained into a copper or wooden trough (such as the copper trough B or C, or the wooden one D, Plate III. Fig. 2); that is, by putting a sieve or linen cloth across the trough, by which means the liquor is cleaned from all the grain and little straws left by the weld in boiling. The liquor thus strained is left to cool till you can bear your hand in it: the silk is then dipped, and returned till the colour becomes uniform (see the manner of returning the silk over a trough in C, Plate II. Fig. 1). If this boiling does not make sufficient to fill the trough, it must be supplied with water, which should be added before the liquor is cold, that the degrees of heat already mentioned should be preserved. In general, all dyeing vessels should be full, that the silk when dipped should be only two inches from the edge.

During this operation the weld is a second time boiled in fresh water, and when it has boiled, the silk should be raised at one end of the trough, either upon a kind of barrow or upon the edge of the trough. Half the liquor is then thrown away, and replenished by adding of the second boiling as much as was taken from the first, observing to rake and mix the liquor well; such is generally the method when any new addition is made, at least if the contrary is not particularly specified. This new liquor may be used rather hotter than

the first; it should, nevertheless, be always of a moderate heat, because otherwise it would destroy a part of the colour which the silk had already taken, probably owing to the silk being deprived of part of the alum by the heat of the liquor. The silk is returned in this fresh liquor as at first; meanwhile you prepare a solution of pearl ash in proportion of about one pound to every twenty pounds of silk.

For this purpose the pearl ash is put into a copper, and the second liquor, quite boiling, poured on it, stirring in order to assist the dissolving of the salt. This small liquor is left to subside, and the silk is a second time raised on the barrow or trough, throwing into the liquor about two or three ladles of the clearest of the solution. The liquor is then well raked, the silk re-plunged, and again returned.

This alkali develops and brightens the yellow of the weld.

After seven or eight returns, one hank is wrung on the peg to try if the colour be full enough and sufficiently bright; if deficient, a little more of the solution of the ashes must be added, and the remainder of the silk done in the same manner till it has taken the shade required.

The lixivium, separately prepared, may be added if you will, at the same time with the second boiling of the weed-liquor; care should be taken, however, that the liquor be not too hot. This operation is only for yellows; nor would the liquor do for greens.

For yellow still fuller, approaching to jonquil, when the pearl ash is added, it may be also necessary to add some roucou, in proportion to the shade required.

We shall hereafter, when treating of orange colours, give the method of preparing the roucou.

For the light shades, such as pale lemon or Canary-bird, they should be boiled in the same manner as for blues, these shades being much more beautiful and transparent when

dipped in a clear ground. See the article on the blue of the the vat.

To do this, when the weld is ready to boil, some of the liquor should be taken out and mixed with a little clean water, and a little of the liquor of the vat if boiled without azure. The silk is then dipped as usual, and if deficient in shade, the weld liquor must be re-added and the dipping repeated if necessary to complete the shade required.

For deeper lemon colours the weld should boil as for yellows, adding only a certain quality with clean water according to the fulness of the shade required; some of the liquor of the vat may also be added if necessary; but these dark lemon colours may be boiled in the common boiling as for yellows. It must be observed, however, that the blue of the vat is never added to these colours but when it is intended to give them a greenish cast.

These very pale yellow shades are rather difficult, as they are very frequently liable to be affected by the air, and to deepen too much while drying. This happens when alumed in the common way, which is too much; but this inconvenience may be avoided, if instead of aluming as for other yellows, a separate liquor is prepared, or even without any particular preparation, only a little alum put into the liquor of the weld.

Remarks on Yellows

In manufactories where they cannot easily procure weld, they make use of the grains of Avignon, and precisely in the same manner; but it gives a less permanent colour.

There are two species of weld: the bastard or wild kind, which grows naturally in the fields, is rather higher than the other, and the stalks much thicker.

The cultivated weld, on the contrary, is the more esteemed

in proportion, as their stalks are shorter and finer. The dyers give it the preference, as it produces more dye than the bastard, and are always careful to choose it very ripe and yellow.

It sometimes comes from Spain, and is very good; but the Parisian dyers use that which grows in the environs of Pontoise, Chantilly, and other neighbouring places, where they sow it in the month of March and gather it in June the following year; it therefore remains all the winter in the ground. Sandy soils are the properest for this plant.

When ripe, it is gathered and dried, and then tied in bunches. The dyers boil the bunches entire, because every part is productive of colour.

Raw silk to be dyed yellow is preferable in proportion to its natural whiteness; it need not, however, be so very white as for blues.

Aurora, Orange, Mordoré, Gold Colour, and Chamois

Roucou, the ingredient producing these various colours on silk, is of the nature of those plants whose colouring particles reside in their resinous substance. It is therefore dissolved by an alkaline salt, as we shall presently mention; nor is there any necessity for the silk to be impregnated with alum; because in general this astringent is only requisite for obtaining and confirming the extractive colours, which are naturally soluble in water.

To prepare the roucou it is necessary to have a large copper cullender about eight or ten inches deep and half as wide, full of holes on all sides, about as large as the small holes of a skimmer, with two copper or iron handles. It is represented in F, Plate II. Fig. 2.

A copper of a convenient size, with either river or any

other soft water, proper for dissolving the soap is heated. While the water is heating, the roucou is cut into bits and put into the cullender just described, called the roucou-pot.

The whole is then plunged into the water by means of a wooden pestle (G, Plate II. Fig. 2); it is dissolved and passed through the cullender. When the roucou is entirely passed, some pearl ashes are put in the same cullender and undergo the same operation. The liquor is then stirred with a rod, suffered to boil once or twice, and then immediately checked with cold water, when the fire is taken from under the copper to prevent it from boiling any longer.

You may dissolve as much roucou as you think proper ; but for every pound of roucou there must be twelve ounces or one pound of ashes ; with less, the colour would not be sufficiently solid, but would change into a brick or tile colour, called *tiling*. As the ashes are not a'ways of an equal strength, the dyer must judge of the quantity requisite to produce the desired effect on the roucou. The effect of the ashes used in dissolving the roucou is to destroy the brick colour, to make it take a beautiful bright yellow, and to render this colour more durable.

If when using the roucou the colour appears to have too much of the brick colour, showing that it wants more ashes, it will be then necessary to make an addition, giving it another boil, and checking with cold water as in the first operation ; it is then stirred with a stick and left to settle.

Roucou dissolved in this manner will keep without spoiling as long as you please, provided care be taken to keep it clean.

Silks intended for aurora or orange colour require only the usual boiling—twenty pounds to one hundred pounds of soap. When these have been washed and the soap beat out, they are drained on the pole, put on the rods in large hanks, and while disposed in th's manner, a copper half-full of river water is

made hot; some of the roucou solution is then put into it, and the whole heated to such a degree that you cannot bear to put your hand into it—but not ready to boil, that is, between hot and boiling; and then having stirred the liquor in order to mix the roucou and water perfectly, the silks are returned.

When they appear even, one of the hanks is taken out, washed, and twice beetled, and then once wrung on the peg to try whether the colour be sufficiently full; if not, some more roucou is added, the liquor stirred, and the silk again returned till equal to expectation.

When finished, the whole is washed and twice beat at the river, which is absolutely necessary to discharge the superfluous roucou, otherwise the silk is liable to smear, and always less beautiful.

The aurora serves as a ground to another colour called *Mordoré.* When the silk has taken the aurora, been washed and alumed as usual, it is then cooled at the river, and a fresh liquor prepared, rather hot, to which is added some decoction of fustic and a little of the logwood decoction. The silk is returned in this liquor; but if apparently too red, by throwing in a small quantity of the solution of copperas you make it sufficiently yellow. The first shades of this colour require nothing more than a little copperas and fustic, which makes them precisely one shade above the aurora.

The alum solution given to the silk after the roucou ground is necessary to extract and fix the dye of the fustic and logwood used in the mordoré, the dye of these woods residing in their extractive particles.

To dye raw silk aurora, it should be chosen for the natural whiteness of its colour, as for yellow; having soaked it you should give the roucou liquor but just warm, or even cold, otherwise the ashes by which the roucou was dissolved would destroy the natural and necessary elasticity of the silk.

For the oranges and mordores, the operation is continued precisely in the same manner as for boiled silk.

When you have but a small parcel of silk to dye, dissolve a proportionable quantity of roucou ; having cooled the liquor with fresh water, it should stand till the grounds sink to the bottom of the copper before the silk is dipped.

What we have hitherto said concerns the silk designed for the aurora shade; but to produce the orange, a shade much redder than the aurora, it is necessary after the roucou dye, to redden the silk with vinegar, alum, or lemon juice. These acids, in saturating the alkali used in dissolving and preparing the roucou, destroy the yellow shade given by this alkali, restoring its natural shade, which is much redder.

Vinegar or lemon juice will suffice to give the orange shade if not very deep ; but for the extreme dark it is the custom at Paris to dip in a solution of alum, which greatly reddens the roucou ; and when still deficient in colour to dip in a weak decoction of Brazil wood. At Lyons they frequently make use of their old liquors as a ground for their saffron colours.

When the oranges are reddened with alum they should be washed at the river ; but there is no necessity for beetling unless the colour be too red.

The roucou liquor which had been used for the auroras is yet sufficiently strong to give the ground for the first shade to the fire colours (of which hereafter), to brighten the deep yellows, and for the gold and chamois, or goat colours. These shades may be made after the aurora without any difficulty, the roucou being of itself sufficient. Nevertheless, the redder shades of the goat colour require reddening as for oranges, unless you choose rather to prepare your roucou on purpose, which is done in the following manner :—

Having dissolved the roucou as above mentioned, it should

boil, but without any pearl ash. When the liquor subsides, a part of it is added to the alkaline solution of the roucou, which, for these goat colours, sufficiently reddens the liquor; nor is there any necessity for putting much pearl ash in the solution of the roucou. These goat colours require to be once beetled when washed at the river.

The roucou is generally brought us in lumps of about two or three pounds, wrapped in large leaves, and sometimes in great lumps without any wrappers. It makes, however, no difference, as the dyers are only attentive to its being of a good flesh colour and free from black veins. The roucou colours are not very solid, changing after some time to a brickish hue and very weak; but it is hardly possible to produce these shades with the ingredients of the lesser dye, because the madder and weld producing auroras and oranges on wool has not the same effect on silk; besides, the roucou colours are very beautiful, and therefore preferable, as in silk-dyeing beauty is preferable to solidity.

Red and Fine Crimson

The colour extracted from cochineal is called Fine Crimson, because of its beauty and solidity; it resides in the extractive matter, is very soluble in water, and upon that account requires the common astringent, which is alum.

Silk intended for the crimson of cochineal should have only twenty pounds of soap to a hundred pounds of silk, and no azure, because the little natural yellow still remaining in the silk, after only this quantity of soap, is favourable to the colour.

Having washed and beetled the silk at the river to discharge it well of the soap, it is put in a very strong solution of alum, where it should remain generally from night till the

next morning, about seven or eight hours. The silk is then washed and twice beetled at the river, during which time the following liquor is thus prepared :—

You fill a long boiler about one-half or two-thirds full of river water ; when this water boils you throw in some white nutgalls pounded, letting it boil a little longer, about a quarter of an ounce to two ounces for every pound of silk. If the nutgalls are well pounded and sifted they may be put in at the same time with the cochineal.

The silk being washed, beetled, and distributed upon the rods, you throw into the liquor the cochineal, carefully pounded and sifted ; it must be then well stirred with a stick and afterwards boiled. You may put from two to three ounces for every pound of silk, according to the shade required. For the most common crimson colours, two ounces and a half is sufficient, it being seldom necessary to use three ounces, except for some particular match.

When the cochineal has boiled, you add to the liquor, for every pound of cochineal, about an ounce of the solution of tin in *aquaregia* ; it is called *composition*, and made in the following manner :—

One pound of the spirit of nitre, two ounces of sal-ammoniac, and six ounces of fine tin in grains : the two last are put into an earthen pot of a proper size ; twelve ounces of water is then poured on it, the spirit of nitre afterwards added, and the whole left to dissolve.

This composition contains much more tin and sal-ammoniac than is used for the scarlet of cochineal on wool ; it is, however, absolutely necessary.

This quantity of the composition should be well mixed and stirred in the liquor, and the copper then filled with cold water, about eight or ten quarts to every pound of fine silk ; coarse silk requiring less, as it occupies less space. The liquor is then

fit to receive the silk, which is immersed, and returned till it appears uniform, generally requiring about five or six returns. The fire is then stirred, and whilst the liquor is boiling, which it should do for two hours, the silk is returned from time to time. The fire is then taken from under the copper, and the silk put to soak in the same manner as for aluming. It should remain for five or six hours, or even, if the liquor be ready at night, till the next morning. It is then taken out, washed at the river, twice beetled, wrung as usual, and put on the perches to dry.

To sadden the grain scarlets, the silk when taken out of the cochineal liquor, is washed and twice beetled at the river; the water liquor is then prepared—in summer as it is, but in winter a little warmed, adding a solution of copperas more or less according to the darkness of the shade required. The silk should be returned in this liquor, in small hanks, till it becomes very even, and when the shade is equal to expectation, should be taken out, wrung and put to dry without washing if you like, because the copperas liquor is little more than clean water. The copperas gives the cochineal a violet tint, depriving it of its yellow. If, however, it should appear to lose too much of its yellow, it may be preserved by adding to the copperas liquor a little of the decoction of fustic. Nothing but copperas will sadden grain scarlets, the logwood being quite useless for this purpose; copperas alone will suffice, as it darkens greatly with the nutgalls used in grain scarlets.

Remarks on Grain Crimson

The process just related for producing this colour is the most in use at present, as it gives a more beautiful shade than can be obtained by any other method. Nevertheless, as many dyers proceed in the old way, we shall describe it here.

For these grain scarlets, the roucou paste as imported from the Indies is added in the boiling of the silk.

When the soap boils, about an ounce of roucou is bruised in the cullender, in the same manner as described for orange colours. It should be pounded as fine as possible, lest any lumps should remain and stick to the silk.

This small quantity of roucou in the boiling of the silk gives it an Isabella colour, tolerably permanent, and has the same effect as the compostion, yellowing a little. The remainder of this process is just the same as the preceding; but without the addition of either composition or tartar.

The silk dyers are accustomed to use only the finest cochineal, and even always prefer the prepared cochineal, which is cleansed from all its impurities, sifted, and picked. This is certainly commendable, considering that the cochineal not prepared being less pure, the more of it must be added, and that the dregs remaining in the liquor may injure the colour.

The white tartar used in grain scarlets, serves to exalt and yellow the colour of the cochineal, producing this effect by its acidity, all acids having the same effect; we must, however, observe that tartar is preferable, as it gives a more beautiful tint.

But notwithstanding the quality of the tartar, it is still incapable of exalting the colour of the cochineal sufficient to produce a grain scarlet, whatever quantity may be added if employed by itself, for if the dose of this ingredient be moderate it will not yellow enough, and if too large it destroys and degrades the colour, without any good effect.

In order to assist the tartar it will be necessary to add some of the composition, which, as we have seen, is nothing more than a solution of tin in *aquaregia*. This solution with cochineal, when used for dyeing of worsted, has a considerable effect, changing it from a crimson, its natural colour, to a prodigious bright fire colour, produces only a crimson when

applied to silk: but it gives this colour a very beautiful tint; for uniting with the tartar it augments the effect without impoverishing the colour, saving the roucou ground as we have before observed.

As to nutgalls, they produce no good effect with regard to colour. On the contrary, if you use too much, they tarnish to a degree, entirely spoiling the colour; nevertheless, it is always the custom to put the quantity we have specified.

One might probably conjecture from the introduction of this practice, that scarlets were formerly produced with cochineal, without either tartar or composition, yellowing only with roucou; silk dyed in this manner, however, would have no rustling, so that it could not be distinguished from silk dyed with Brazil wood. Nutgalls, on account of their concealed acid, having the property of giving the silk a great rustling, is therefore aided with cochineal, by which means these scarlets are distinguished by the fell from the scarlet of Brazil wood; for we must observe that the Brazil dye cannot stand the action of the nutgalls, by which it is entirely destroyed.

But besides giving this rustling to the silk, it has at the same time the singular and very remarkable quality of adding to its weight very considerably, so that by putting one ounce of nutgalls to every pound of silk, you add 2 or $2\frac{1}{2}$ per cent. to the weight; by this means some silk dyers add even 7 or 8 per cent. They are so much accustomed to this advantage in weight, owing to the nutgalls, that even when this drug becomes useless, by the addition of the tartar and composition, which produces the same rustling, they make it still necessary on account of the weight, which is not proportionably increased by the other acids. White nutgalls are always preferable to the black, as they injure the colours much less. We may, however, hence conclude that for grain scarlets nutgalls are not only useless but very prejudicial, and serving

only as an imposition, is a blamable practice, injurious to commerce, and therefore that in case of any new regulation in the art of dyeing silk, it is to be hoped that this drug in the production of fine scarlets may be absolutely prohibited.

The silk is thus suffered to remain in the liquor in order to make it wholly imbibe the cochineal; during this repose it takes a good half shade, and the colour yellowing in proportion, gives it a much finer cast.

One would be apt to believe that leaving the silk to boil in the liquor for a longer time would have the same effect; but experience proves the contrary; besides, it would be more expensive, considering that it would be necessary to continue the fire.

The cochineal leaves on the silk when taken out of the liquor a kind of scale, or rather the skin of the insect, which always contains a portion of the colouring juice. In order therefore to cleanse the silk perfectly from this kind of bran, it is twice beetled when washed at the river. By this means the colour becomes more brilliant, clearer, and fuller.

The two beetlings before dyeing are necessary, because the silk having been strongly alumed for this colour, and intended to boil in the dyeing liquor for a great while, would without this precaution yield a certain quantity of the alum, which not only injures the colour, but likewise prevents the perfect extraction of the cochineal, for generally all neutral salts added to the dyeing liquor have more or less this inconvenience.

The grain or cochineal crimson, such as described, is not only a very beautiful, but may be considered as a most excellent colour; it is the most permanent of all dyes for silk. It perfectly resists the boiling with soap, and evidently suffers no alteration from either the sun or the air. Silk stuffs of this colour, commonly used in furniture, are sooner worn out than faded. It is frequently seen that the colour of this grain

crimson in furniture, though more than sixty years old, is scarce impaired. The only observable difference occasioned by time, is that by losing the yellow cast it becomes rather darker, approaching nearer to the violet.

Good judges need only handle grain crimson to distinguish it from the false dye of the Brazil wood, of which hereafter; for this last colour not bearing the acids, the silk cannot have that rustling and firmness given by the acids used in grain crimson. When the silk is fabricated into stuff, and the buyers are doubtful concerning the dye, let them try it with vinegar. If dyed with cochineal it will stand the test, but if with Brazil, it instantly spots yellow, and the colour is destroyed.

Of False Crimson, or the Red of Brazil Wood

This wood furnishes an extractive dye in great abundance, and tolerably beautiful, though evidently inferior to the cochineal. It is called false crimson on account of its little solidity, compared with the grain crimson; but being infinitely cheaper is consequently very much used.

Silk intended for the Brazil red should in the boiling have twenty pounds of soap to every hundredweight of silk; it should be alumed as usual, but there is no occasion to make the aluming so strong as for grain crimson. When the silk is alumed it should be wrung and cooled at the river.

During the time of washing, some water is heated in a copper; meanwhile a trough is prepared with a strong decoction of Brazil wood, about half a bucket to every pound of silk, more or less according to the strength of the decoction and the shade required; a proper quantity of warm water is then poured into the trough. The silk is afterwards dipped and then returned, as the yellows; in this liquor it takes a red, which if hard water has been used, is generally of the crimson

shade; but if soft water, this red is yellower than the crimson of cochineal, which it is always meant to imitate as much as possible. For this purpose it always requires saddening, which is done in the following manner:—

A small quantity of pearl ash should be dissolved in warm water—one pound may suffice for every thirty or forty pounds of silk. The silk is then washed at the river, once beetled, and the lixivium of the kelp put into a fresh trough and filled with cold water. In this water the silk is dipped. It immediately takes a beautiful grain tint, leaving in the water a little of its dye. After this the silk is washed at the river, then wrung, and put on the rods to dry.

In some manufactories, instead of using pearl ash in saddening, the silk is dipped in hot water only, till it has acquired the proper shade; but this operation is a great deal more tedious and more extravagant, considering the consumption of the wood; it has therefore no advantage over the preceding, especially as it necessarily requires more dye, the warm water greatly discharging the colour.

In others, it is the custom to crimson in the same liquor in which it was dyed, by adding to it a little of the lixivium; this is by much the shortest method, though not often used, because it requires more ashes, and the scarlet done in this manner is never so handsome.

It is well known that for pale shades nothing more is required than to put less of the Brazil decoction to the liquor; but this is seldom practised, because the colours are not beautiful.

Remarks on the Red or Crimson of Brazil Wood

This colour is not difficult, neither is it attended with embarrassment. The silk dyers are always provided with the decoction of Brazil, which is made in the following manner:—

The wood is cut into small chips; about a hundred and fifty pounds of these chips are put into a copper containing about sixty buckets. The copper is then filled, and the chips boiled for three hours, supplying the water as it evaporates. Some of the decoction is then turned into a barrel, and as much more clean water poured on the chips, which are suffered to boil three hours longer, and this repeated till it has had in all four boilings, after which the wood is exhausted of colour.

It is a custom with some dyers to preserve these different boilings separately; the first is the strongest, but not often the most beautiful, because loaded with the impurities of the wood. The last is generally the clearest and weakest; it has been found, however, that by mixing them together they make a homogeneous liquor that is very useful.

Probably by washing the wood in hot water previously, a juice might be obtained that would give rather a finer colour; but this would be of too little importance to warrant so much trouble and so many precautions. It is nevertheless proper to take off the black scum that is upon the surface of each decoction; the colour will be much the more beautiful.

This Brazil decoction is commonly kept a fortnight or three weeks before it is used, because it has been observed that it undergoes a kind of silent fermentation, which greatly improves the colour. It is even the custom with some dyers to leave it stand four or five months, till it becomes fat and oily; but it has never been observed, at least with regard to silk, that it is better for keeping so long. A fortnight or three weeks, as we have already said, is quite sufficient to give it all its quality. If used when newly made, it gives a more rosy colour, and a greater quantity is necessary, because then the dye is much weaker.

With regard to the decoction of the Brazil wood, it may be made either with river or well water. The only perceptible

advantage in the use of well water, either in the decoction of the wood or in the liquor, is that the red does not require to be crimsoned with the pearl ashes; we must, however, observe that the reds made with river water, and afterwards saddened with ashes, have a more pleasing effect to the eye.

Under the general denomination of Brazil wood are comprehended a variety of species, which though all apparently producing the same colour, are nevertheless very different, both in respect of the beauty and goodness of the colour. The most beautiful, and for silk the best, is called *Pernambuco.* This wood is also the dearest, very heavy, imported with the bark, and is extremely brown. When first cut down it is more yellow than red at the inside, but by being exposed to the air it gradually becomes redder. Its colour, however, is never very deep. The cleanest, freest from knots, and the highest in colour is the best.

Silk dyers seldom make use of the wood of *St. Martha,* which differs from the preceding by being redder and deeper; it may, nevertheless, be used with advantage for very dark colours. They certainly make great use of it for calicoes and cottons.

There is, besides, another wood more like the Pernambuco, called *Sappon wood* or *brésillet,* but as it gives less colour it is only used for the lighter shades. The Pernambuco, however, may be used with more advantage even for those shades, the colour of the Sappon being extracted with great difficulty.

This wood may be easily distinguished from Pernambuco, being much paler, and the logs not so large; it is a little pithy at the inside.

Browns and false reds are commonly called brown reds, because in the dye-houses crimsons are called false reds.

In making these shades, when the silk has imbibed the Brazil to a sufficient degree, some decoction of logwood is added to the liquor, more or less according to the shade required.

If deficient in the violet tinge, a little of the lixivium may be added to the water, as for false crimson.

To dye this false colour in the raw, the silk should be naturally as white as for yellow. When soaked and alumed, the process is the same as for boiled silk.

Of Scarlet, Orange Red, and Cherry Colour

These colours are a variety of lively reds, heightened by a tinct yellower than crimson. They are easily yellowed on wool, or vivified with the composition or solution of tin. Upon this substance it produces great brightness and solidity, the cochineal from which it is extracted being an ingredient essentially good. But it is far from producing the same effect upon silk, this substance absolutely refusing to take these shades from cochineal; hitherto, at least, nothing has been published to this effect. [*About ten or twelve years ago a dyer produced on velvet a fire colour, as he said, dyed with cochineal. All we can learn of the secret is, that he gave it a strong roucou ground, and that after washing he gave it the cochineal liquor, adding a small quantity of the solution of tin.*] Silk, when dipped in a cochineal liquor and exalted by the tin composition, capable of producing on wool the brightest fire colour, imbibes only a weak onion shade, tarnished and, properly speaking, a wretched daubing.

It therefore becomes necessary to make use of another drug, or the flowers of a plant called *Carthamus bastard saffron* or *saffranum*.

This flower contains two sort of dyes, very distinct and different from each other both in colour and property. The one is a kind of yellow of an extractive nature, consequently soluble in water; the other a fine strong red, much yellower than scarlet, the natural shade being an extreme lively and

agreeable cherry colour. These last colouring particles of the Carthamus, being decidedly of a resinous nature, will not dissolve in water only, as we shall presently see.

Though the natural shade of the resinous red of the Carthamus, not being yellow enough, requires a yellow ground to imitate the fiery scarlet of cochineal on wool, yet the yellow extract is useless, not being sufficiently fine nor of a proper colour; it is therefore necessary to begin by separating the extractive yellow from the resinous red, which on account of the different nature of these two dyes, is by no means difficult. For this purpose it requires only to dissolve and discharge the extractive yellow by a sufficient quantity of water, What remains afterwards is the resinous red, and must, in order to render it capable of dyeing, be dissolved by means of an alkaline salt, as we shall see in the following detail:—

Preparation of the Carthamus or Bastard Saffron

This Carthamus, about fifty or sixty pounds at a time, is enclosed in strong linen sacks and carried to the river, choosing a good bottom free from stones. The sacks are put into the water, and to prevent them from being carried away, are carefully tied at one end with a cord, which cord is fastened to a stake. A man then gets upon the top of the sack, taking a long stick in his hand by way of support, and keeps continually treading with his feet.

If it be warm weather and no great quantity of the Carthamus to wash, the operation may be done with naked legs and wooden shoes; but if cold weather and a great quantity to wash, it will be necessary to have strong leather boots, sufficient to resist the water.

By this means a great quantity of the yellow is carried off

by the water, the man still continuing to tread the sacks till the water is no longer coloured.

This is a tedious operation, generally requiring a man for two days to wash one sack of sixty pounds.

If it happens that you have good running or well-water within reach, it would save the trouble of washing at the river, and may be done in troughs as follows :—

Troughs for this purpose (marked A, Plate VI. Fig. 1) are made of good planks, commonly six feet long and three feet and a half broad, that the sacks may be put in and removed with ease.

When the sack is put in it is opened at the end, and kept open with a cross piece of wood (see B, *ibid.* Fig. 2), or by some other method. One of the cocks (C) in the dye-house is let run into this opening, and as soon as the saffranum is sufficiently soaked, a man provided with boots, as we have already said, holding a rope fastened to the ceiling, treads it with his feet till the yellow colour is discharged from the saffron (see this manœuvre at D, *ibid.*).

When the water is very yellow it is let out by means of a cock or bung-hole near the bottom of the trough, which should slant so as to let the water run off more easily (as may be seen at E, *ibid.*). Fresh water is then put to it, when it is again pressed and the water again let out, and so continued till the saffranum is entirely washed and no longer colours the water.

This method of washing the saffranum is much more convenient than the other, and therefore practised wherever there is a good spring or well water within reach, particularly at Lyons, where there is water and dye-houses proper for this work. The sacks used in the washing are always dyed a cherry colour, because the extractive yellow is dissolved, and with it exudes a small portion of the resinous red of the saffranum.

When this substance is thus freed of its yellow, it is prepared for dyeing in the following manner :—

It is put into a trough made of deal, such as those used for dyeing ; but as the carthamus is in lumps, these lumps are divided and broken with a pestle. When perfectly separated it is strewed over at different times, and well mixed with pearl or kelp ashes, pounded or sifted—about six pounds for every hundred of saffranum (as in F, *ibid.*).

It is then collected in one corner of the trough, pressing it by small parcels with the feet, and throwing it behind to the other end of the trough (see G, *ibid.*).

The saffranum is then put into a long small trough, called a grate, because the bottom is formed like a kind of trellis with wooden bars, about two fingers' breadth from each other, which is the breadth of the bar. The inside of this trough is lined with a linen cloth stretched and filled with saffranum ; this trough is then placed in a larger trough, and cold water thrown over it. This water impregnated with the salts, retains in solution the colouring substance of the saffron, which fritters into the larger trough or receiver (see this apparatus marked H, *ibid.* Figs. 1 and 2). You continue thus to pour on fresh water, stirring from time to time, till the under trough is full ; the saffranum is then carried to another trough, more water poured on it till it begins to take no more colour. A little of the ashes is then readded, and more water till it has still less colour. This manœuvre is continued till the saffranum is entirely deprived of its red, retaining only the yellow, when it is good for nothing.

Silks intended for poppy or fine fire colour should be previously boiled as for white ; they should then have a roucou ground three or four degrees under the shade called aurora, as explained in the article upon "Oranges." There is no occasion

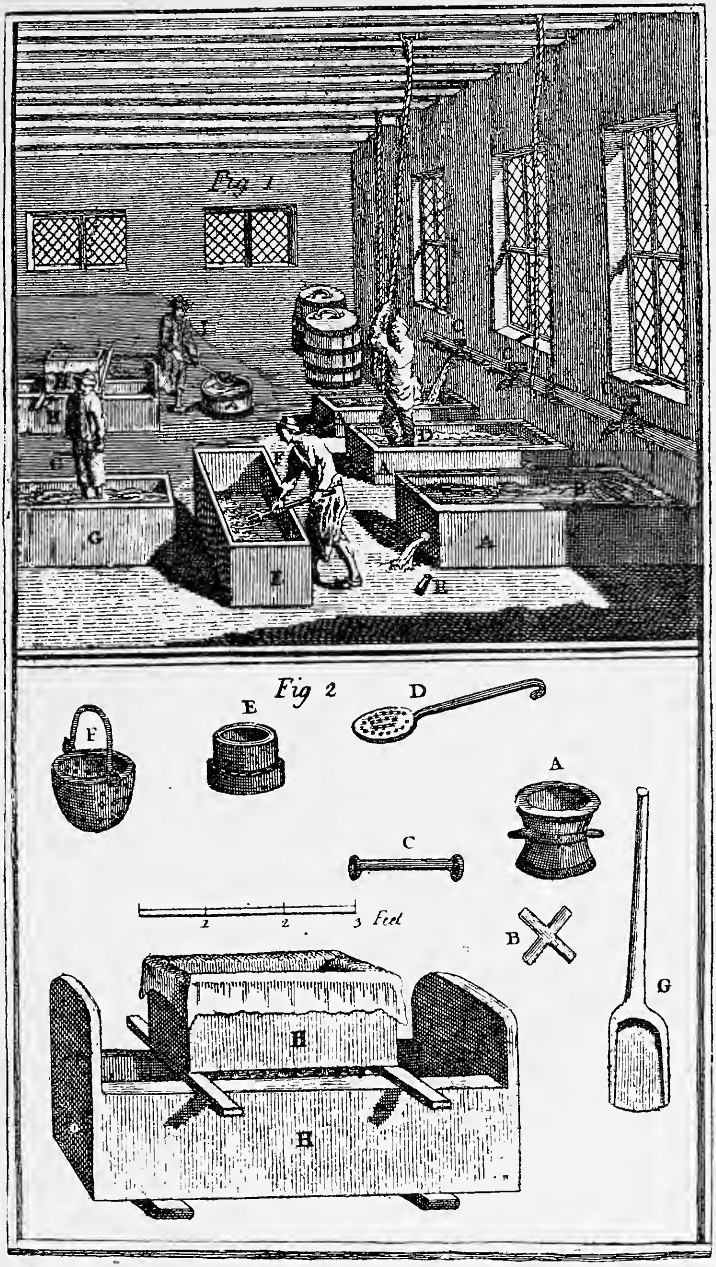
Fig 1
Fig 2
A
B
C
D
E
F
G
H
H
1 2 3 Feet

for aluming, those silks being intended only to take the resinous colour.

When the silks are washed, well drained, and the hanks distributed on the rods, some lemon juice is added to the liquor, till the colour, which was before a reddish yellow, becomes a beautiful cherry colour : this is called turning the liquor. The whole is then well stirred, the silks put in, and returned till they have taken the colour.

It is necessary to observe that the poppy is the fullest colour which bastard saffron is capable of producing ; and that when the silk apparently imbibes no more colour, it is taken out and wrung with the hand over the liquor, drained on the pegs, and plunged into a fresh liquor as strong as the first. This process is the same as the former ; it is taken out, washed, wrung, and spread on the rods to dry. When dry it is again dipped in fresh liquor as at first, and this is continued in the same manner, washing and drying between every fresh liquor till it has acquired the fulness you desire. It generally requires four or five liquors before it obtains the fire or poppy colour ; this, however, depends on the strength of the liquor, and if the saffranum lixivium be weak, it will be necessary to dip oftener ; but however strong it may be, you can hardly produce this colour under three or four liquors.

The silk having acquired sufficient fulness, it must be finished in the following manner :—

Some water being heated till ready to boil, is then put into a trough, and some lemon juice added (the quantity, about half a pint for every bucket of water). The poppy colours are then returned in this briskening liquor, which at the same time serves for washing, by which means they become brighter and more gay ; they are then wrung and dried as usual.

The process for dark oranges and deep cherry colours is precisely the same as for poppies, only that it is unnecessary

to give the roucou ground, and that the liquor used for the poppy will do for these colours till entirely exhausted. No fresh liquors are made for these colours but when you have none of the liquors used for poppies ready.

Light cherry colours, rose colours of various shades, and flesh colours, require only the second or last liquors that were drained from off the saffron, which are the weakest; these colours are, however, worked and brightened in the same manner as the poppies, dipping always the deepest first after the poppies.

Flesh colour is the lightest of these shades, and so extremely delicate that a little of the soap water used for boiling the silk is added to the liquor. The soap softens and prevents the silk from taking the colour too quick and uneven. They are washed and then brightened in the same liquor that had been used for the darker colours.

These liquors require to be immediately worked, and always as quick as possible, as by keeping they lose their colour, and after a certain time are entirely spoilt.

They are always used cold, because the saffranum reddened by the lemon juice will not bear heat.

To save the saffranum, it has been the custom for some time past, for poppies and deep colours, to use the herb archil; about five or six buckets of this herb liquor added to the thirty buckets of the first or second saffron liquor, making about a fifteenth part of the whole. When we come to speak of archil we shall give the method of extracting its colour.

To produce the saffranum colours on raw silk the whitest is preferable, and is treated in exactly the same manner as the boiled, with this difference only, that the poppies, oranges, and cherry colours in the raw are generally dipped in liquors that were used for the same colours for boiled silk; these liquors being still sufficiently strong for dyeing raw silk, which,

as we have already said, rises in colour with less difficulty, and even in general requires less dye than the boiled.

Remarks on the Dye of Carthamus or Bastard Saffron

When the Carthamus is divested of all its extractive yellow, the resinous red still remaining requires a particular solvent; fixed alkaline salts we know by experience are the fittest for this purpose. A kind of lixivium therefore, consisting of kelp or pearl ashes, is the necessary solvent for reducing the resinous red of Carthamus into a proper solution for dyeing; but this alkali, at the same time that it dissolves the resinous red, greatly diminishes the intensity of the colour, giving it a yellow cast, as we have seen with regard to the roucou. This inconvenience is, however, entirely prevented by adding the acid of lemon juice to the liquor, which, separating the colouring resinous particles from the alkali, establishes the colour in its original beauty.

The resinous red is in fact no longer in a state of solution, but is rather a kind of precipitate. This precipitate, however, is so fine and so divided as to be equal to a solution. It must, however, be observed that when the silk remains in this dye for any time it ceases to imbibe the colour, even though the liquor should still retain a large quantity; this is doubtless occasioned by the avidity with which the silk imbibes the finer particles, the other being too gross, especially when the silk is saturated to a certain degree.

All acids are capable of giving the proper degree of colour to an alkalised Carthamus liquor. Mineral acids are certainly much cheaper than lemon juice; nevertheless the latter has been always preferred, as evidently producing a better effect.

The poppy colours are entirely produced without archil; being sufficiently supplied with the red of Carthamus only,

and when its highest perfection is a colour very bright and beautiful. It will not, however, bear to be compared with the fine scarlet of cochineal upon woollens; the astonishing brightness of the latter must always make it appear weak and faded.

Poppy colours resist vinegar; they are much more expensive, more beautiful, and more permanent than the bad fire colour of Brazil wood, called false poppy. They are for this reason considered by most of the silk dyers and manufacturers as a fire colour of the best dye; but they by no means deserve to be ranked with firm and permanent dyes. Twenty-four hours' exposure to the sun and open air is sufficient to degrade the finest of those poppies by three or four shades; and if for some days exposed, scarce a vestige of the colour remains. Deep oranges, cherries, and rose colours, being less charged with the Carthamus red, are still sooner degraded and destroyed by the air.

The red of Carthamus being of a nature truly resinous, is therefore soluble in spirit of wine; this solvent instantly discharges the colour.

The False Poppy, or Fire Colour, produced with Brazil Wood

The Brazil wood produces a kind of fire colour called *ratine*, or false poppy; infinitely cheaper, less beautiful, and still less permanent than that of the Carthamus or saffranum.

This colour is produced on boiled silks as for common colours. It should have the roucou ground of a tolerable shade, stronger than for the fine poppy, because the red of the Brazil wood is yellower than that of the saffranum; the shade given by this ground is almost a demi-aurora. It is, however, advisable, as well for the false or solid poppy, when a proper ground is

obtained, to keep a skein by way of pattern, which skein may serve as a future guide.

This ratine, or false poppy, is obtained without much difficulty. Having boiled, as before expressed, washed, and given the roucou ground; again washed, and once or twice beetled at the river, it is then alumed as for all extractive colours, the Brazil being of that number. Afterwards it is cooled at the river, and then dressed as usual. The Brazil decoction is then prepared with hot water, and a little of the soap water, which had been kept on purpose, is then added to the liquor, about four or five quarts to a trough containing five-and-twenty or thirty pounds of silk. The whole is then stirred, and the silk put into it.

If after a certain number of returns the colour appears still faint, a little of the Brazil decoction is then added. When the colour is even you leave it to imbibe the dye, returning the silk from time to time till it has acquired the proper shade.

When finished and washed at the river, if apparently deficient in red, it may be once beetled ; but it is first necessary to observe whether, as is generally the case, the water rouses the red of the Brazil. If it has not this property, instead of beetling the silk, more of the Brazil decoction should be added till it has acquired sufficient colour.

By this method ratine colours are produced still browner, and totally different from the fire-colour shade.

In order to brown when the Brazil liquor is exhausted, a part of it is thrown away and another portion of the Brazil decoction readded; afterwards a decoction of the logwood, which browns more or less according to the quantity added.

These are the truly brown ratine colours, for some time past called by the name of mordoré,—a name, however, not applicable, and appertaining to the colour mentioned under the article "Aurora."

These ratine browns, as well as the red browns, under the article of "False Scarlets," serve to complete the various shades of the poppies and oranges which cannot be obtained from the saffranum.

We have nothing to add to what we have already said, when speaking of scarlets, with regard to the Brazil liquor. This decoction is necessary for every colour where the Brazil is used, nor is there any difference but in the manner of using it. For instance, the soap added to the Brazil liquor, in order to produce the ratine or false poppy, is designed to render the silk soft and pliant, and to deprive it of the stiffness which it would otherwise have without this precaution; the aluming given upon a roucou ground producing this stiffness. Some dyers, instead of the soap, throw in a small quantity of nutgalls powdered; they fancy that it produces the same effect, and even adds to the brightness of the colour; but the greater number prefer soap.

For the ratine in the raw you take the whitest, as for yellow; having soaked and given the roucou ground only warm, or even cold, not to ungum the silk; this colour is afterwards finished as boiled silk.

False Rose Colour

It is by no means the custom to make false orange or cherry colours, because the colours produced in this manner are too dull and ugly. False rose colours only are obtained by boiling as for poppies; afterwards aluming, and then dipping in a very light Brazil liquor without any other addition; but as this colour is very grey, and absolutely deficient in brightness, it is but seldom used.

To dye this shade in the raw, it is necessary, as for all delicate colours, to choose the whitest; when soaked it is dyed in the same manner as the boiled.

Of Green

This colour, composed of blue and yellow, is with difficulty produced on silk, because the blue vat is liable to spot and to give a party colour, an inconvenience more perceptible in green than blue. Greens are produced in the following manner:–

The boiling of the silk for this colour is the same as for common colours.

Silk dyers distinguish a multitude of green shades; we shall, however, mention only the principal, and of these no more than is necessary.

We shall first speak of the sea green, or Tourville green, consisting of twenty-five or thirty gradations, from the weakest, called pistachio green, to the deepest shade, called terrasse green.

To produce these greens, after boiling, the silk is strongly alumed; it is then cooled at the river and distributed into hanks of about four or five ounces. This precaution is necessary for giving the yellow ground to all silk intended for green; because thus distributed in smaller hanks, the silk is more equally dyed, which, with regard to green, is of the greatest consequence. The weld is then boiled, as in the article upon "Yellow."

The weld having boiled, a liquor of it is prepared with clean water strong enough to give a good lemon ground. The silk should be then returned in this liquor with great care; because an uneven ground would be very discernible in the green. When the ground seems nearly full enough, some threads of the silks are dipped in the blue vat to try whether the colour of the ground be sufficiently full for the shade. If not, some of the weld decoction is added and again tried. When the colour comes good, the silk is cooled at the river, and if you

will, once beetled; it is then wrung and formed into hanks convenient for dipping in the vat. Being dipped skein by skein as for blues, it is wrung with equal care and quickness.

The fifteen or sixteen lighter shades of this green require only to be dipped in the vat to be completely finished. As to the pistachio green, if the vat be yet too strong, as soon as taken out, it should be carefully opened and aired, but not washed. It is then worked in the hands; that is, held with one hand and struck with the other, by which means the silk being disentangled and aired, the colour becomes equally clear. A few threads are then rinsed, and if the colour be right the whole is washed.

For the dark shades, when the weld is exhausted, a little logwood is added to the liquor.

For the darkest shades it is even necessary to add some decoction of fustic; the silk is afterwards washed and beetled as before, and then dipped in the vat, always remembering to wash and dry quickly.

There are many other shades, differing from the sea green because they have a yellow cast; they are, however, produced by the same ingredients, for example, the willow green.

These greens are dipped in a very strong weld liquor, and when exhausted the fustic or roucou is added to the same liquor in order to complete the shade; if the colour requires darkening, a little logwood may be added after the fustic or roucou; they are afterwards dipped in the vat.

The second shade of green is the meadow or emerald green. These are alumed as for sea greens; after having cooled at the river it is dipped and returned in the weld liquor, which had been previously used for the sea green. When the colour seems even, some threads are put into the vat to try the effect of the ground; if the green be too blue, it is again put into a fresh decoction of the weld. The vat is then stirred, and the

silk again put in, till by making a fresh essay on the vat, you find the ground proper to the shade required.

The only difference between the meadow and emerald grounds is, that the first is rather the darkest.

In manufactories where savory is easily procured, it is used for these kinds of shades in preference to the weld, the savory naturally yielding more juice than the weld, or rather because the stuff when dry retains the same colour which it had taken in the liquor; whilst, on the contrary, the colour of the weld always grows yellower and redder in the drying.

In case of necessity *genestrole* may be substituted for savory, having the same effect as the weld, with this difference only, that as it is less productive more of it must be used. These colours should be always washed and dried as quick as possible, as should all greens and blues in general.

The third shade is the duck green, and produced with the weld, savory, or *genestrole*, by giving a good ground of these ingredients, and when the colour is exhausted it may be darkened by adding some logwood to the same liquor; it is afterwards dipped in the vat.

The *oeilet* green is produced in the same manner as the meadow and emerald green, with this difference only, that the gradations or shades are made by dividing the ground; that is, by giving the ground more or less strength according to the different shades, whereas of the emerald and grass green there are no gradations.

The duck-wing shades are darkened by an addition of logwood, as in the preceding shades.

The celadon requires much less ground than the other shades, because it has a great deal more blue. The darkest shades of this colour are produced by the help of logwood.

Apple green is the precise intermediate shade between the oeilet and the sea green, and requires the same process. The

various green grounds hitherto mentioned, except sea green, should be given in liquors that had been already used, but which contain neither logwood nor fustic. The old liquors should therefore be carefully preserved.

Remarks on Green

The effects of the weld and genestrole being, as we have already observed, nearly similar, are almost indifferently used, and even sometimes mixed together. With regard to the savory it is certainly preferable for green shades to the other two, except for those where it is necessary to add either logwood, fustic, or roucou.

Besides these greens there are a multitude of others all under the denomination of those already mentioned. We shall therefore only remark that for the very dark shades approaching to black, copperas may be used after the other ingredients are exhausted. For the very clear shades of the celadon and other light greens, the silk should boil twice, as for light blues, these light shades being thereby rendered much more lively and transparent.

Of Olives

Silks for this colour require only the common boiling. When strongly alumed, and cooled at the river, they are then dipped in a very strong liquor of the weld, in the same manner as for yellows, adding to this liquor when exhausted some logwood, and when the logwood is exhausted a little of the lixivium of pearl ash. This alkali greens the liquor, giving it an olive cast. The silk is again dipped in this liquor, and when of a proper colour, taken out, washed, and put on the rods to dry.

There are two shades of olive. One the green olive above

mentioned, the other is a reddish and rusty olive. For this second shade having given the weld, some fustic and logwood may be added, but without the pearl ashes. If the colour be too red, the logwood only should be added, and also without pearl ash.

For the clear shades of these colours you *divide* or diminish the logwood; that is, allowing less for the clearest and more for the darkest shade.

Remarks on Olives

Though the olive be a species of green, it is not, however, the custom to give it the blue vat, because the colour would then be too green. The logwood, which naturally gives a violet by the addition of pearl ash, becomes blue, and this blue when combined with the yellow of the weld gives the green necessary for producing this shade.

Fustic gives a colour commonly called drabolve, because generally made to match with olive in cloth, which has generally more red than the preceding.

Having alumed as usual, the silk is then dipped in a fustic liquor, with the addition of copperas and logwood. When this liquor is exhausted it is thrown away, and a fresh one made similar to the first, remembering only to rectify the quantities of the ingredients. If the colour be deficient in some parts, it is again dipped as at first, till the shade is properly full. Both liquors should be of a moderate heat.

The green dye for raw silk is in the manner as for boiled; the whitest, as for yellows, are the best; having prepared and alumed, the remainder of the process is the same as for boiled.

Of Violet

Violet is a composition of red and blue. The blue of all violets is obtained from indigo; the red from cochineal, besides several other ingredients from which it may be extracted.

When the red is obtained from cochineal it is a good dye, and is called fine violet, but if from any other drug, particularly archil, the colour has but little solidity, and is called false violet.

Of Fine Violet, or Violet in Grain

For this colour the common boiling is used; the silk is then alumed as for fine scarlet, and when washed at the river should be twice beetled.

The silk thus prepared is cochinealed as for crimson, with this difference, however, that neither tartar nor composition is added to the liquor; these acids being used in crimson only to exalt the colour of the cochineal by giving it a yellow cast. For violet, on the contrary, the natural colour of the cochineal is best, having a great deal more of the violet, more purple, and more of the gillyflower colour, and therefore more or less of the cochineal is required according to the intensity of the shade. The common quantity is two ounces for every pound of silk.

In making the cochineal liquor, the copper designed for it should be half-filled with water, in which the cochineal should boil for about a quarter of an hour. Meanwhile the silk is passed on the rods in small hanks, the same as for giving the ground for greens; the copper is then filled with cold water, because the liquor should be just warm: the silk is then returned in the liquor with care and great accuracy, and if twenty rods or more, it will be necessary to keep two men in

returning the silk, that the colour may be more perfect and more equally imbibed.

As soon as the silk appears sufficiently even the fire should be stirred to make the liquor boil, and then one man is sufficient to return, which should be continued with accuracy to the end of the liquor, which generally lasts about two hours, as for fine crimsons.

If after two hours boiling it appears that the liquor is not yet sufficiently exhausted, the silk may be put into an alkali during five or six hours, as before directed when speaking of crimsons. The silk is afterwards washed at the river and twice beetled ; it is then dressed and dipped in the vat, more or less strong in proportion to the shade of the violet colour required.

Washing and drying are usually done in the same manner as for blues and greens, and in general for all colours dipped in the vat.

The dyers are accustomed to use a little archil in the production of these shades, in order to give them strength and beauty. It is added to the cochineal liquor, after it is exhausted, what quantity you think proper, according to the shade required. Having boiled for about a quarter of an hour, it should be then suffered to stand till the archil sinks to the bottom, and then the silks are returned in the liquor.

This method is, however, blamable, because the colour procured from the archil is a false dye, and should not therefore be ranked with a fine colour and good dye, such as the violet of pure cochineal.

The custom of uniting archil with the cochineal in the production of fine violets has crept in by degrees, because the red of the cochineal in these colours is much less beautiful to the eye, or rather because the merchants and manufacturers of silk stuffs giving the preference to brightness and beauty, the dyers are partial to this manœuvre ; besides, the archil

being much cheaper than the cochineal, many dyers insensibly increase the quantity of this false ingredient, proportionably diminishing the cochineal in such a manner that their pretended fine violets, and sold as such, are really no more than a species of false violet. This has become a shameful abuse, and certainly ought to be discouraged. Nevertheless, the admission of archil seems indispensably necessary in weak shades, especially light violets, as the colour imparted by the cochineal is insupportably tarnished and dull. They are therefore under the necessity of producing light shades with archil, which always imparts a very beautiful though a very perishable colour.

It has been already observed in the article on "Blue" that it is impossible to produce the darkest of these shades by the help of indigo alone, and therefore that it is necessary to join it with some dark red; this red may be extracted from the cochineal, and the dark blues darkened by this ingredient are termed *fine blues*, to distinguish them from the blue darkened with archil, a drug of false tinct: these dark blues are evidently rather a species of violet.

The fine blue is alumed in the same manner as the fine violet, in like manner washed at the river, twice beetled, afterwards alumed, and the quantity of the cochineal is one ounce or an ounce and a half in proportion to the shade required, remembering to divide the silk into small hanks as for violet. They are then washed and twice beetled; after which they require nothing more than to be dipped in a fresh vat.

Of False and Common Violets or Lilac

False violets are procured in various ways and from different kinds of ingredients, of which in their proper order.

The finest and most in use are procured from archil. This

ingredient is of the moss and lichen kind, an herb, in its natural state, imparting no colour to water. It is therefore necessary, in order to render it of any use, to open and dissolve its colouring principle by means of digestion and a kind of fermentation, assisted by a mixture of urine and lime. The method of preparing archil for dyeing is very clearly and exactly related by M. Hellot in the foregoing treatise on dyeing wool. The colouring particles of this drug seem of a resinous nature, not dissolving in water, but through the medium of an alkali; therefore substances to be dyed with archil require no aluming. The following is the process for dyeing with this ingredient.

A copper is boiled with a quantity of the archil in proportion to the colour required; a full and dark violet requires a larger quantity, sometimes two, three, or even four times the weight of the silk, according to the goodness of the archil and the fulness of the colour.

During the preparation of the archil liquor the silk is taken out of the soap, cleansed, and afterwards drained and dressed by hanks as for fine violet. The hot archil liquor is then taken off clear, leaving the grounds at the bottom, carried and put into a trough of a convenient size, in which the silk is returned with the greatest accuracy.

When the colour is come to, you make a trial of the vat, to try if it be sufficiently full for a very dark violet; if too light, it is again dipped in the archil liquor, adding fresh archil if necessary; when it is of a proper colour it is twice beetled at the river, and then dipped in the vat as for fine violets.

The washing and drying of this colour is the same as for all colours dipped in the vat. The different shades of violets are distinguished by different names: those above described are called violet of Holland, and are the fullest, the richest, and most beautiful colours.

The bishop's violet, which is the second shade, has also a full ground; but less of the vat, by which it preserves a redder cast.

As giving the blue in lilac requires great management, and that the vats are generally too strong, it is the custom, in order to be master of these shades, to mix a little of the new vat with some pearl ash in clean water, to prepare a liquor on purpose, by which the lilacs may be blued or reddened at pleasure. For this purpose it is necessary to take a new vat in all its vigour, because those which have been already worked and tired, give no more, even though a quantity be added, than a greyish colour, and that not permanent.

When the vat is added to this liquor, and immediately raked, the mixture becomes of a green colour, which diminishes insensibly. The silks are not dipped till the liquor begins to lose a little of this previous green, and inclines to the colour of indigo, because if dipped before, they would be exposed to take an uneven colour; for when this liquor is in all its green, consequently in all its vigour, the first portion of the silk dipped in it seizes the colour with avidity, by which means the liquor is so much exhausted of its green that the silks afterwards dipped have a vat incapable of giving a strong blue.

The pearl ash added to this liquor helps in bluing the archil, because the general effect of all alkalies is to render all reds violet. It is not therefore added to the archil liquor, because in boiling together it would injure and in part destroy the effect of the colour. We have already prescribed a warm liquor for reddening and bluing, as water too hot would be alone sufficient to weaken the archil ground, and with more reason would produce this effect when aided by an alkali; but in case of necessity, warm water may be used for this operation.

These colours, when finished, are wrung over the liquor,

and afterwards on the peg, but without washing, because the greater part of the blue would be lost in the washing. The silk is afterwards put to dry in a covered place, the action of the air being alone sufficient to change them considerably; particularly the violets and lilacs of archil, especially when made of the best kind, growing in the Canaries, called herb archil, which, though more beautiful, is at the same time the least permanent of all the various colours in dyeing. Acids destroy them, and they so quickly fade that to keep silks of this colour, if you would preserve them fresh, it is necessary to keep them as much as possible from the air.

Of the Violet of Logwood

To dye violet with logwood, the silk should be boiled, alumed, and washed as usual.

The logwood is cut into chips, and boiled in water as already described with regard to the Brazil wood. The decoction when made is put into a barrel to be ready upon occasion.

When used for dyeing, it is put into a trough with a quantity of cold water, in proportion to the quantity of silks to be dyed, to which is added and well mixed some of the decoction of the logwood, more or less according to the shade required; the silks are returned in this cold liquor till they have obtained the colour you would have. This liquor gives a less beautiful shade than the archil, and a little dull.

Remarks

The natural colour of the logwood or *campêche* is a very brown red. The highest coloured, the soundest, and the least loaded with sap, is the best. It makes a dark brown-red decoction.

The silk for this dye should be alumed, without which it would be only daubed with a reddish colour, and would not even bear washing, the dye of this wood being of an extractive nature.

But when alumed, the silk in this dye takes a tolerable good violet, a little less durable than that of the archil; but will in some degree stand the soap, which gives it a blue cast.

This dye should be used cold, for when hot it gives a rough colour, very uneven, more tarnished, and less beautiful.

For this reason the decoction should be made two or three days before it is wanted. It is, however, necessary to observe that the logwood decoction will not keep so long as that of the Brazil wood, as it changes by time, taking a fawn tinge, which spoils it, and therefore no more of it should be made than may be wanted in the course of three weeks or a month.

Violet of Logwood and Verdigris

A violet may also be obtained from logwood and verdigris as follows:—

The silk is washed from the soap, and drained on the peg, etc. You then dissolve in cold water about one ounce of verdigris for every pound of silk; when it is well mixed in the water, the silk is immersed, and may remain in this liquor for an hour, or till it is well impregnated with the verdigris. This gives no perceptible colour. The silk is after this wrung, and again put on the rods. A logwood liquor is then made as for the preceding violet; the silk is dipped in it, and takes a blue colour sufficiently dark.

The silk is then taken out, and when dipped in a clear solution of alum, made either with the liquor or clean water, acquires a red that on the previous blue produces violet.

The quantity of alum thus added is undetermined; but the more alum the redder the violet. The silk having acquired the colour you wish, is wrung over the liquor, washed, and again moderately wrung on the peg, that the colour may remain even in the drying, which when wrung hard is not the case; for then the part most squeezed is lighter than the other parts, which are dark and coppery, an inconvenience to which logwood colours are most liable. Violets with logwood only, without verdigris, require the same attention.

These logwood violets, with verdigris, have neither more beauty nor more solidity than violets without this ingredient. We must, however, observe that the verdigris with which the silk is impregnated serves as an aluming preparation towards receiving the logwood dye; besides, this colour being absolutely blue, the alum afterwards added serves only to give that redness peculiar to violet. Hence it is evident that a colour truly blue may be obtained from verdigris and logwood; this, however, is a very false colour, and by no means comparable to the blue of the vat, either in beauty or solidity.

Violets of Brazil Wood and Logwood

Silk for these violets must be alumed and cooled as usual; it is then dipped in a liquor of the Brazil wood of the common heat; when it has imbibed this liquor, a decoction of logwood is added, and the colour being properly full, is then changed by adding some lixivium of pearl ash; it is afterwards washed, wrung, and dried as usual.

Remarks

The violet produced by the Brazil and logwood is much redder and more beautiful than that obtained from the logwood

only, though not more durable ; it is even more easily injured by soap.

Though this violet is produced by two ingredients, it is nevertheless necessary to use them one after another ; because if mixed, the colour would be uneven.

Neither is it a matter of indifference which of those liquors should be first applied. Begin therefore with the Brazil, remembering our former observation, that the silk when impregnated with the logwood dye, takes the Brazil with more difficulty, probably proceeding from the avidity with which the logwood seizes the alum, not leaving sufficient for the Brazil. It is besides necessary, if you begin with the logwood, to give it cold, because of its inequality when hot. The combination of these two woods only, produces a violet ; nevertheless you add to its brightness by the pearl ash, which greatly enlivens the colour, making it more purple.

Instead, however, of adding the pearl ash, it is sometimes more advisable to make a clear liquor for this change. This practice should be more especially observed when particular shades are to be matched, especially when you are apprehensive that the silk is overcharged by remaining too long in the dye.

It is generally thought sufficient only to wash these shades at the river without beating ; it may, however, be necessary to beetle when washing, particularly if the colour appears dark or dull, as by this means all impurities are carried off and the colour brightened.

Violets from Brazil Wood and Archil

For this violet, as for the preceding, having boiled and alumed the silk, it is dipped in a clear liquor of Brazil wood, or in a liquor that had been used for reeds ; it is then beetled

at the river and dipped in the archil to fill the colour. It is afterwards washed a second time and again beetled. After this it is dipped in the vat, wrung, and dried with the same accuracy as greens and blues.

This last resembles the fine Holland violet made with the archil and the vat only. The Brazil previously given helps to save the archil; but as these violets are always inferior to the Holland, this process is never practised except for the darker shades, which can be obtained by no other means. The dye of the Brazil begins to give the silk a strong ground; nevertheless it is no impediment to the effect of the archil afterwards.

These violets are prevented from having the brightness and beauty of the Hollands by the aluming necessary required for extracting the Brazil, the alum hence acquiring the property of making the archil rusty, or of giving it a yellow cast unfavourable to this colour.

To dye violets in the raw the silk should be as white as for yellow. When dipped, the process is the same as for boiled silk, each according to the shade required. The fine violet is not usually practised on the raw.

Of Purple, Gillyflower, and of Fine Cochineal or Purple

The silk for these colours is boiled as usual, and alumed as for fine violets; the cochinealing also in the same manner:—the common quantity of cochineal is two ounces, more or less according to the shade required. The silk having boiled for two hours in the cochineal liquor, is taken out, washed, and beetled at the river. If a purple violet inclining to blue is wanted, it requires only to be dipped in a weak vat. In this case, as we have before observed, it is necessary to wring and dry with all possible expedition, this precaution being absolutely necessary for all colours dipped in the vat; there is, however,

no necessity for dipping in the vat except for purples and the darker shades, the others requiring only to be dipped in cold water with a little of the liquor of the vat, as they always acquire too much blue when dipped in the vat, though ever so much exhausted.

To assist the turning of these colours, a little arsenic may be added to the cochineal liquor, about half an ounce to every pound of silk. The light shades are done in the same manner, remembering to put less cochineal; the shades under purple are those called gillyflower and gris-de-lin; those under gris-de-lin are called peach-blossom. The gillyflower requires no turning, nor even the other shades if not too red, in which case they may be turned with a little of the liquor of the vat.

Of False Purple

These false purples are alumed as for the common Brazil colours; when given a slight Brazil liquor, the silk is once beetled at the river, and afterwards dipped in the archil liquor, stronger or weaker according to the shade. The Brazil given before the archil is necessary, because the colour of the archil alone would be too violet.

For browning the dark shades, logwood is used, either in the Brazil liquor if required very dark, or if not quite so dark, in the archil.

The lightest of those shades may be produced with Brazil only, and afterwards turned with clean water, with the addition of some pearl ash; but as this method rather hardens the silk, it were more advisable to give them a little of the archil liquor after the Brazil; nevertheless, if the colour be too violet it may be reddened with a little clean water and a little vinegar, or lemon juice.

The false gillyflowers may be produced by the archil only,

omitting the previous dye of the Brazil, as for purples, and therefore there is no necessity for aluming. If not violet enough you give it a little pearl ash ; the light shades are produced in the same manner, only with weaker liquors.

Fine purples, or fine gillyflowers, are not customary in the raw ; but with regard to false shades the silk should be of the whitest, as for common colours. After soaking it should be treated as boiled silks.

Of Maroons, Cinnamons, and Wine Lees

These colours are obtained from Logwood, Brazil, and fustic.

For cinnamon colours the silk is boiled as usual, then alumed, and then a decoction of these three woods made separately. The fustic decoction makes the base of the liquor, to which is added about a quarter of the Brazil decoction, and about an eighteenth of the decoction of logwood.

This liquor should be of a temperate heat ; the silk is then returned, and when the liquor is exhausted and the colour equal, it is wrung in the hand ; it is then put on the rods, and a second liquor made, in which these three colouring ingredients are proportioned according to their effects in producing the shade required. Fustic evidently gives the yellow, Brazil the red, and logwood the darker shades, of which these colours are composed.

Maroons are produced in the same manner precisely, except that these latter shades being darker and less red, the logwood should predominate over the Brazil, remembering always to keep a just proportion of the fustic, which gives the ground to each of these colours.

The plumb juice, wine lees, etc., should be done in the same manner and with the same ingredients, altering only the proportion as occasion requires.

Remarks

The fustic decoction should be made as it is wanted only, because it very soon changes and spoils, becoming slimy, tarnished, getting an olive cast, and no longer producing the desired effect. This decoction, however, though thus changed, may be almost entirely restored by reheating, and then may do well enough for these colours.

Many dyers wash the silk, out of the aluming, at the river before it is dipped, and then by one liquor produce these several colours; but the following method seems better, because the first liquor being a sufficient wash, and the silk retaining more of the alum, takes the dye better. Besides, as it is impossible to produce these shades but by perpetual handling, the second liquor may be useful in rectifying the defects of the first, and in finishing the colour, especially the fustic ground, which requires the alum to assist it in rousing sufficiently.

The maroons and cinnamons may be obtained by a different method. When the silk is boiled, the grounds of the roucou should be again dissolved in the same soap which had been used for the boiling, by straining it, as before described, through the roucou pot; and when boiled for about a quarter of an hour, it should be left to settle. The silk is then returned in this liquor without having been washed, which gives it a yellow ground. It is afterwards washed and beetled at the river, and then alumed as usual. After this, the fustic, Brazil, and logwood liquors are given for the cinnamon; but for the maroon, the Brazil is omitted, unless they seem to want red, remembering that the aluming considerably reddens the roucou. If they are too red, though without the Brazil, a little of the solution of copperas added to the liquor will check the red,

give it a greenish colour, and at the same time darken it sufficiently, particularly if it has had any quantity of the logwood ; it is therefore necessary to be sparing of the logwood, that you may be able, by means of the copperas, to correct the too great redness of the roucou.

This method may be more advantageous than the first, considering that the roucou, reddened with alum, is much more solid than the red of Brazil. A little roucou, however, may be added without soap, as for ratines.

For maroons and other browns in the raw, the silk may be used in its natural colour, because the yellow is no way prejudicial to these shades ; on the contrary, it may answer the purpose of a ground. Having dipped as usual, the process is the same as for boiled silk, each according to its shade.

Of Nut Greys, Thorn Greys, Black and Iron Greys, and Others of the Same Species

All these colours, except black grey, are produced without aluming. The silk being washed from the soap and drained on the peg, a liquor is made of fustic, logwood, archil, and copperas. Fustic gives the ground ; archil the red ; logwood darkens ; and the copperas softens all these colours, turns them grey, and at the same time serves instead of alum in extracting these several colours. As there is an infinite variety of greys without any positive names, and produced by the same methods, it would be endless to enter into a detail that would prolong this treatise to so little purpose.

Suffice it to remark here, that in producing a reddish grey the archil should predominate ; for those more grey, the logwood ; and for those still more rusty and rather greenish, fustic.

In general, when obliged to complete the colour with log-

wood, it should be used rather sparingly, because it is apt in drying to darken too much, differing in this particular from all other colours.

To give an example of the manner of producing these colours, we shall take the nut grey.

The fustic decoction, archil, and a little logwood is put into water moderately hot. The silk is then returned, and when the liquor is exhausted it is taken out, and to soften the colour the copperas solution is added. Some dyers for this purpose add the black wash instead of the copperas; the silk is again returned, and if the colour does not appear sufficiently even, some red spots still remaining, it may be concluded that it requires a little more copperas.

It must also be remembered, that as copperas is the general base of all greys, if deficient in quantity, the colour will be apt to change in drying, and to become rough and uneven.

To try if the colour be sufficiently softened, it should be examined, and if it wets easily after having been wrung on the peg, it wants copperas, but if, on the contrary, it soaks with a little difficulty, the colour is enough softened.

On the other hand, too much copperas stiffens the silk considerably, making it harsh, and even depriving it of a great part of its lustre. To remedy this, the silk when taken out of the liquor should be wrung on the peg, and then immediately washed at the river, which carries off the superfluous copperas.

The black greys, because alumed and welded, make a separate class. When the silk is alumed and cooled at the river, and the weld liquor prepared as for yellows, the silk is returned, and when the liquor is exhausted a part of it is thrown away, and the logwood decoction substituted in its place. The silk is again returned in this liquor, and when

the logwood is exhausted, some copperas may be added in a sufficient quantity to blacken the colour. The silk is then washed, wrung, and finished as usual.

For iron grey it is necessary to boil the same as for blues. This colour is much more beautiful when laid on a very white ground. It is more used in the manufacturing of stockings than any other colour, therefore generally wrought in shades; that is, many different shades made at the same time.

When the silk is washed and prepared as usual, you make the liquor of river or well water, no matter which; but either must be cold.

If river water, the logwood decoction made with river water is added, sufficient to produce the dark shade required; the silk is then dipped, and when finished it is wrung and hung up. A part of the liquor is then thrown away and replenished with water for the following shades, and so on to the lightest, carefully dividing, that is, preserving an equal distance between the shades.

When all is finished with the logwood, the dark shades are put again on the rods, to be dipped in a new liquor with the addition of copperas; the remaining lighter shades are then dipped in the same liquor, but without the copperas addition: if, however, the second shade is not enough softened, a little copperas must be added. This defect is easily perceived in the dipping, as we have before observed.

When arrived at the lightest shades, care should be taken that the liquor be not overcharged with copperas, which is easily perceived by its having a reddish cast, in which case some of the liquor should be thrown away, and replenishing with water, too much copperas producing the same effect with regard to these shades as the preceding.

When the liquor is made with well-water, the logwood decoction should also be made of well-water. This being added to the liquor, the darkest shades are first dipped, as in the preceding process. When the silk has sufficiently drawn it is taken out, and the following shades are then dipped, but without replenishing, the colour being much better and clearer without the river water.

When all the shades are complete, you soften with copperas in the same manner as above described; the silk is afterwards washed, and, if necessary, beetled.

To discharge greys, as well as maroons and cinnamon, etc., that is, when the shades are too dark and too full, you put some tartar pounded in a mortar and sifted into a bucket or small trough; you then pour over it some boiling water. The clearest of this liquor is afterwards put in a trough, and the silks returned in it, by which operation a part of the colour is immediately discharged.

If the silk does not instantly take an equal colour, a little more tartar must be added, as above mentioned.

The silk thus discharged of its superfluous colour is once beetled at the river, and afterwards dipped in hot water, without any other addition. This last operation restores in part what it had lost by the tartar; but to try the colour, it should be wrung on the peg.

The tartar always destroying some part of this colour, it should be restored with a fresh liquor made for the purpose, and then softened with copperas as usual.

If the silk has been alumed, then the hot water may be omitted after the beetling; the hot water is, however, always of use in removing the harshness occasioned by the tartar.

To discharge iron greys, when too dark, they should be

sulphured, afterwards beetled at the river, and then again dipped in a fresh liquor similar to the first.

This method of discharging iron greys is preferable to either tartar or lemon juice, these ingredients giving them a ground that does not easily yield even to the boiling with soap, which consequently spoils the colour; whereas the sulphuring almost entirely whitens the silk by totally destroying the logwood.

For greys in the raw, the silk should be as white as for common colours, except the black grey, for which the natural yellow would be no disadvantage. Having soaked the raw silk, the process is then the same for producing these shades as on boiled silk.

Of Black

Black is rather a difficult dye on silk. We have at least reason to think so, considering the numberless experiments and inquiries that have been found necessary in the attainment of a good black, and if we may judge from the multitude of ingredients that are admitted into the composition of this colour.

The base or foundation of the black dye is generally composed of ingredients commonly used in making of ink, viz. iron dissolved by acids and precipitated by a vegetable astringent.

Different manufactories have different methods of producing this colour, though all agree in nearly the same base or foundation. We shall, however, describe the process as practised in many respectable dye-houses, and in which we ourselves have been very successful, notwithstanding its many apparently superfluous ingredients.

Twenty quarts of strong vinegar are put into a trough with one pound of black nutgalls pounded and sifted, and five pounds of fresh iron filings. While the infusion is making,

you clean out the copper, in which you put the black ground, with the following drugs pounded, viz:—

8 lb.	of	black nutgalls.	3 lb.	of	agaric.
8	,,	cummin.	2	,,	*Coque de Levant.*
4	,,	sumach.	10	,,	buckthorn.
12	,,	pomegranate rind.	6	,,	linseed.
4	,,	bitter apple.			

These several drugs are put into a copper containing half the quantity of the vessel used for the black ground, and filled with water. Twenty pounds of *campêche* or logwood chips are afterwards enclosed in a linen bag, for the conveniency of taking them out of the liquor, unless you choose to take them out with a pierced ladle, or any other means, because these must boil a second time as well as the other drugs.

When the logwood has boiled for about a quarter of an hour it is then taken out and properly preserved. The above-mentioned drugs are then put into the logwood decoction, and also boiled for about a quarter of an hour, carefully checking with cold water as often as it seems ready to boil over.

This operation being finished, the liquor is strained through a linen strainer into a trough and then left to settle, carefully preserving the grounds, which must be again boiled.

The cold infusion of the vinegar with the nutgalls and iron filings is then put into the copper intended for the black ground. The fire is afterwards put under it, and the following ingredients immediately added, viz:—

20 lb.	of	gum arabic pounded.	2 lb.	of	green copperas.
3	,,	realgar or red arsenic.	2	,,	the scum of sugar candy.
1	,,	of sal-ammoniac.	10	,,	powdered sugar.
1	,,	sal. gem.	4	,,	litharge pounded.
1	,,	mineral crystal.	5	,,	antimony.
1	,,	white arsenic pounded.	2	,,	orpiment.
1	,,	corrosive sublimate.	2	,,	plumbago.

These several drugs should be pounded and sifted, except the gum arabic, which is only broken.

Instead of gum arabic the native gums may be used, and dissolved in the following manner:—Some of the logwood decoction is put into a boiler; when hot, you put into it a copper strainer, made in the shape of an egg and open at the largest end (see this utensil in F, Plate VI. Fig. 2). The gum is put into this strainer, and dissolves as the liquor heats; it must be stirred with a wooden pestle that it may pass through the holes. When it is entirely passed you introduce another copper strainer, with holes still smaller than the former, to prevent the impurities of the gum from escaping. The liquor of the gum already dissolved is poured into this strainer and again passed as before, by the help of the pestle. This operation is made more easy by now and then taking out the strainer and resting it on a cross-shelf or plank suspended on the peg over the copper used for wringing the black. The gum must be squeezed pretty hard with the pestle, to force it through the holes of the strainer.

The gum would dissolve with more facility if previously steeped for three or four days in the logwood decoction, especially if you are careful to pour it on very hot.

When the above ingredients are put into the black ground, you must remember to keep the liquor hot enough to dissolve the gum and the salts, but it should never be suffered to boil; and when it is therefore sufficiently hot, the fire is taken away and the fresh iron filings sprinkled over it, in a proper quantity to cover the liquor.

The next morning the fire is again put under the copper, the drugs boiled, and the logwood a second time boiled. It is then taken out and the following drugs added to this second decoction, viz.:—

2 lb. of black nutgalls pounded.	1 lb. of bitter apple.
4 ,, sumach.	2 ,, agaric pounded.
4 ,, cummin.	2 ,, *Coque de Levant.*
5 ,, buckthorn berries.	5 ,, linseed.
6 ,, pomegranate rinds pounded.	

These drugs are boiled, the liquor strained and poured in the black ground as we have already said, and the grounds preserved. You then put a little fire under the copper as at first, and the following drugs are immediately added, viz.:—

8 oz. of litharge pounded.	8 oz. of rock salt.
8 ,, antimony pounded.	8 ,, fenugrec.
8 ,, *Plumb de mer,* also pounded.	8 ,, corrosive sublimate.
8 ,, white arsenic pounded.	8 lb. of copperas.
8 ,, crystal mineral.	20 ,, gum arabic, prepared as above.

When the liquor is hot enough you take away the fire; strewing over the liquor with the iron filings, and letting it stand for three or four days.

Two pounds of verdigris are then pounded and dissolved with six quarts of vinegar in an earthen pot, adding to it about an ounce of cream of tartar. The whole should boil for a full hour, taking care to check the boiling with cold vinegar, that it may not boil over; this preparation should be kept ready to be added to the black ground when you are going to dye.

For the black dye the silk is boiled as usual; having washed and beetled according to custom, you give the gall liquor for heavy blacks twice, but for light blacks only once. These two blacks are alike both in beauty and shade, differing only in the weight of the silk: the light black has, however, rather more lustre.

The nutgall liquor is made as follows:—For every pound of silk you must have three-quarters of a pound of light nutgalls, adding the same quantity of aleppo. These galls are

pounded together, and boiled for two hours in a quantity of water sufficient for the whole of the silk to be galled. As the liquor wastes a great deal in the boiling, it is, after the first hour, filled again, and after two hours the fire is taken away; the liquor is then left to deposit, and the galls taken out with a pierced ladle; about an hour afterwards the silk is put into it, prepared in the following manner:—

During this operation the silk is drained on the peg, put on the cords as for boiling, and only very lightly squeezed: it is then immersed in the gall liquor on cords one above another, taking care to keep it near the surface of the liquor, but sufficiently covered. In this manner it should remain twelve or fifteen hours: it is then taken out, washed at the river, and if intended for heavy black, is a second time galled in a fresh galling, like the first; the grounds are generally used for the first galling; but for the second, a liquor of fresh drugs.

Some dyers gall the heavy blacks but once, by boiling the old grounds, taking them out immediately, and afterwards adding fresh galls; for every pound of silk, a pound of light gall, and half a pound of fine aleppo. The fresh galls they boil for two hours or more, and when the grounds are taken out they put the silk in the fresh gall liquor, where they let it remain a day and a night.

This method, they say, is the best, because were the gall grounds to remain in the liquor, they would reimbibe part of the substance which they had before given to the water.

When the silk is galled, a little fire is put under the black ground; while it is heating, the silk is wrung out of the galling and beetled at the river.

When washed it is drained on the pegs, passing a thread round every hank, each hank as large as for common colours; it is then immediately put on the rods.

While the black liquor is heating it should be stirred with

an iron rake or paddle, to prevent the grounds from sticking to the bottom of the copper. You then dissolve some French gum by the method above described, till it rises on the top in a kind of scum covering the surface of the liquor; afterwards, you throw into it two or three handfuls of linseed. You then add half of the vinegar and verdigris preparation, with about four or five pounds of copperas; this should be punctually repeated at every heating.

Care should be taken whilst the fire is under the copper to rake, and to try if it be hot enough the rake is moved round at the bottom of the copper; if the gum sticks to the rake, and that the liquor does not appear through the middle of the gummy scum, it shows that it is hot enough: the fire is then taken away, because, as we have before observed, it should not boil. The rake is then also taken out, and the liquor covered with the iron filings in the same manner as before; after this it is suffered to subside for about an hour, when the surface of the liquor is again stirred, in order to precipitate the filings to the bottom.

Before we explain the manner of dipping silk in the black liquor, it is proper to observe that silk dyers never dye black but by coppers, that is, when they have a sufficient quantity of silk for three dips, if for heavy black; but if light black, only two dips, which is done in the following manner:—

If heavy black, a third of the silk is put upon the rods, and three times returned in the black ground; it is afterwards wrung on the peg over the copper; this is done by giving it three twists. In this manner three hanks may be wrung at once, because it should be done gently, and only to drain; it is again put on the rods, and suspended between two perches to air.

While the first silk is airing, the second part is dipped in the same manner, and afterwards the third part, always

in the same manner. It must be remembered that while the silk is on the rods it should be turned from time to time, to give it air.

When the last third part is wrung, the first part is put in, and then the two others successively for three times, always airing at each time. This is commonly called giving the three wrings, and these three wrings are called one fire or heating.

The light blacks should also have three wrings to one fire.

After each fire the black ground is again heated, adding copperas and gum as before. This operation is thrice done for the heavy blacks, that is, three fires, each fire consisting of three wrings; but for light blacks only twice, each also consisting of three wrings.

It must be observed that at every reheating it is requisite to change the order of dipping in such a manner that each may in its turn have the first of the liquor. If the black dye is strong and good, the heavy blacks may be done with two fires only; and for the light blacks, one wringing less may do for each heating.

When blacks are finished they are returned in a trough of cold water by dips one after another, called by the French dyers *disbrodure*, or rinsing; they are then twice or thrice beetled at the river. When washed, you put them on the cords, only taking care not to press them too much.

Softening of Black

The silk when taken out of the black dye is extremely harsh, which is by no means wonderful, considering the number of acids and corrosives in the composition. It is therefore necessary to soften in the following manner:—

Dissolve about five pounds of soap in two buckets of water, and while the soap is dissolving, throw in a handful of aniseed

or any other aromatic plant. It should boil till the soap is entirely dissolved. In the meantime a trough should be provided full of water, and large enough to dip all the silk at the same time. The soap water should be strained through linen, the whole mixed well together, and the silk put in, where it should remain a full quarter of an hour. It is then taken out, wrung on the peg, and dried as usual. As the quantity of soap can do no harm, too much is better than too little. The softening is very necessary, in order to divest the silk of that rustling and stiffness so prejudicial in the manufacture of black goods.

Black in the Raw

To dye black in the raw, the silk should be galled in a cold liquor of fresh galls, which had been previously used for the boiled silk. The natural yellow of the silk is preferable for this dye, because the white takes a less beautiful cast.

Having untied the silk and divided it into hanks of the common size, it is dipped with the hands into the gall liquor. When soaked and a little squeezed, it is strung on cords, eight or ten hanks together.

They are afterwards put into the cold gall liquor, one above another, letting even the cords sink in the liquor, where they may remain for six or seven days. They are then taken out and once beetled at the river. As to time, it should remain in the galling according to the strength of the liquor and the quantity of the silk put into it; but however strong it may be, and however small the quantity of silk, it should remain two or three days at least.

When the silk is washed, it is again strung on the cords and left to drain after which the cords are put one over the other into the rincing or black wash, which is of itself sufficient

to dye; it will however require more or less time according to the strength of the rinsing wash, generally about three or four days. Whilst the silk is thus immersed in the rinsing water, it should be raised with sticks three or four times a day; it is then drained over the liquor, and when drained, put on the ground on a proper place, where it is spread and aired, but not dried. This is absolutely necessary to produce the black, else the silk might take a black grey; this grey would, however, blacken in the air. Nevertheless you are thereby enabled to judge how much of the colour it has taken, and how much it may still want. Should the silk be suffered to dry, it must be again wetted before it is re-dipped, which would be an additional and unnecessary trouble. This operation of washing and drying must be successively continued till the silk is sufficiently black.

The silk in this situation is carried to the river, and twice beetled, after which it is drained on the cords and then put on the perches to dry, without wringing, which would soften it too much; for as this kind of silk is designed for gauzes and black lace, care should be taken to preserve its natural stiffness as much as possible.

To produce black in the raw in the quickest manner, the silk when washed from its galling should be put on the rods and three times returned in the blacking ground; it is then taken out and put to drain over the vessel containing the black liquor, and then cooled on the rods.

When drained, it is again twice dipped in the black liquor, drained, and each time cooled as at first. When drained it is again washed, and the procedure is then the same as for those which had been dyed in the rincing. This is not, however, the usual method of dying black in the raw; because it consumes the black liquor too soon, considering with what avidity the raw silk takes any colour whatever; and besides that,

a good *disbrodure*, or rinsing, is sufficiently strong for dyeing this colour.

The black dye is weakened and becomes exhausted in proportion to the silk it has dyed; it is therefore necessary to strengthen and replenish from time to time by an addition of proper drugs, which is called giving the *brevet*, or composition.

This composition is made by putting four or five buckets of water into a copper, and then boiling it with about four pounds of logwood chips. The logwood is then taken out, and four pounds of black buckthorn berries is added, with two pounds of pomegranate rind, two pounds of sumach, two pounds of *Coque de Levant*, two pounds of coliquinte, two pounds of linseed, and four pounds of cummin.

These drugs are boiled together for about three-quarters of an hour; the fire is then put under the black liquor. When a little more than half-boiled, and whilst hot, the following drugs are added, viz.:—

2	lb. of	realgar.	1	lb. of	white arsenic.
4	,,	antimony.	1	,,	corrosive sublimate.
1	,,	gold litharge.	1	,,	orpiment.
1	,,	silver litharge.	1	,,	powder sugar.
1	,,	sal-ammoniac.	1	,,	funegrec.
1	,,	rock salt.	4	,,	copperas.
1	,,	chrystal mineral			

These drugs, when all pounded, are thrown into the black ground, remembering to stir. When the composition is sufficiently boiled it is strained in a trough and left to settle; the grounds having subsided, the clear part is added to the black ground. The same grounds are again boiled and preserved for some other time.

The composition being added to the black liquor, and sufficiently hot, the fire is taken away. The liquor is then strewed over with the iron filing, and left to settle for two days.

When the black ground has had a certain number of additions, and a quantity of sediment collected at the bottom, part of the grounds should be taken out in order to clear the liquor. Thus frequently replenishing, the foundation is always preserved, so that the liquor is never entirely new ; but having been once set in a dye-house is set for ever. These liquors are never liable to putrefaction, owing to the great quantity of nutgalls and martial vitriol in the composition, two of the most powerful antiseptics known.

Remarks on Black

It has been already remarked that amongst the numberless drugs in the composition of this colour, we may reasonably suppose that several of them are useless. This, however, may be easily ascertained by a comparison with the following process for Genoa black.

The most material observation concerning the black dye is, that in general it greatly injures the goods, in such a manner that stuffs of this colour, though not inferior in other respects, wear out much sooner than those of any other. This defect may be attributed to the vitriolic acid of the copperas, which is but imperfectly saturated with the iron. Iron combined with any, even vegetable acid, is capable of producing black with vegetable astringents. It is therefore most probable that this inconvenience might possibly be removed by substituting other combinations of this metal for the copperas, if it were, however, worth while to make the attempt.

From what has been said concerning the process of dyeing black, it is very evident that great care should be taken to dip the silk in the black at three different times, and to open and air it between every dip. This infinitely contributes to the beauty of the black, so different in this particular from

all other colours, which lose a great part of their intensity in drying. It is a well-known fact that good writing-ink improves by the air, and that it is never so black when fresh and first used as it appears afterwards. So with regard to the black dye, for silk, though no more than a greyish black after the first dip, acquires a beautiful black on being exposed to the air. The blue vat is an additional instance of the effect of air on colours, as the silk, though green when dipped, becomes almost immediately blue on being exposed to the air.

PARTICULAR PROCESSES

Communicated by M. Hellot [1]

According to the letters of M. Grange, correspondent of the Royal Society, who died at Schiras in Persia, June 1737, the dyers of the city of Damas dyed their crimson colour so beautiful, and so much esteemed in the East, in the following manner:—Take ten *rottes* (a rotte weighs five pounds) of silk in skeins; wash it well in warm water; then let it soak in a sufficient quantity of hot water during half an hour; squeeze out the water; dip it afterwards, but once only, in a hot lixivium made with a sufficient quantity of water, half a *rotte* of kelp ashes for every *rotte* of silk, which is immediately drained on rods, taking care not to leave the silk longer in the lixivium than is necessary for its being well soaked, lest the alkali should corrode it.

Whilst the silk drains they prepare another liquor cold, with ten ounces of the pulp of yellow melon, very ripe, which is uniformly diffused in a sufficient quantity of water. They

[1] None of the following processes were published; they were taken from the manuscripts of M. Hellot, and never before communicated to the public.

steep in this liquor the ten *rottes* of silk for twenty-four hours; they increase or diminish the quantity of the above drugs in proportion to the quantity of the silk to be dyed. The silk having remained one day in this melon liquor, is several times washed in fresh water till it becomes perfectly clean; they then hang it to dry. Meanwhile the workmen fill a large pan of water, adding a half *rotte* of alum powdered for every *rotte* of silk. The pan is then suspended over a hot furnace, and the liquor boiled during twenty minutes, after which the fire is taken from the furnace. The silk is then dipped in this alum solution, moderately hot, and again taken out as soon as it is perfectly wet. They then put it into another pan, pouring over it the alum solution, in which it remains four or five hours but no longer. It is then taken out and several times washed in fresh water.

Whilst the silk is washing, a workman fills a large pan with water, adding an ounce of *baisonge* (a fungus) finely powdered for every rotte of silk; when this new decoction has boiled for half an hour, they add ten ounces of *oudez* (cochineal) very finely powdered for every rotte of silk; that is, six pounds four ounces of cochineal for ten rottes of silk. As soon as this cochineal is added the fire is taken from the furnace. The liquor is then gently stirred round with a stick, and when the mixture is perfectly made, they pour gently and by inclination a little fresh water into the middle of the pan. The water thus added not only cools the dye but makes it much more lively. They then immediately dip the silk four or five times, wringing after every dip. This tincture is afterwards boiled again for about a quarter of an hour, and the fire is then taken from the furnace as before. When the liquor is a little cool they dip the silk, still observing to wring after every dip. This done, they put the silk into an empty kettle, pouring over it the remainder of the dye, in which it is left

to soak for four-and-twenty hours. It is then well washed in clean water, dried in the shade, and when very dry wove into stuffs. This crimson is much superior to all the French and Italian crimsons, because the silk was never boiled in the dye.

The dyers of Damas and Diarbequir say that they could not accomplish this dye without the pulp of the yellow melon in the preparation, or without the *baisonge* used with the cochineal in the dye. According to M. Grange, we have this melon in France; but he doubts concerning the *baisonge*, which is a species of fungus growing on trees in some parts of Persia, from whence it is brought to Damas, and might also be sent into France, by the way of Aleppo, were we desirous of imitating this excellence in the crimson dye.

To avoid mistakes in the quantity of the different ingredients employed in this process, it may be necessary to repeat that a *rotte* of silk weighs five French pounds, and that the ten rottes of silk produced as an example in this memoir, should also serve as a standard with regard to the quantities of the other ingredients.

As to the water necessary for the preparation of the silk, with the kelp, melon, and the alum for the dye, it requires no more than a sufficient quantity for wetting the silk, namely, about a finger's breadth over it, differing from the tincture, which as the skeins are dipped in this liquor at least ten or a dozen times, should be fuller in the kettle.

The kali used in the preparation of the silk is nothing more than the ashes of a plant, called by the Arabs *kailou*. These are preferable to the ashes made from the *rouquet*, or those made in Egypt.

The frames used for these silks are similar to the frames used at Lyons.

Genoa Crimson (a Process proved in May 1743)

At Genoa the silks designed for crimson are boiled in a much less quantity of soap than those intended for any other colour; eighteen or twenty pounds serving for a hundred pounds of silk in the crimson dye; for any other colour, the Genoese use forty or fifty.

When the silk is boiled it is dipped in the alum liquor, and to a quantity of raw silk, weighing seventy-two pounds, they put from sixteen to eighteen pounds of roche alum, finely powdered, into a copper full of cold water. When the alum is perfectly dissolved the silk is put to soak in it for near four hours; it may remain longer without any inconvenience; silk intended for crimson requiring more alum than for any other colour. When taken out of the alum liquor it is shook and dressed on the pegs, but without wringing. One of the dyers being questioned why the silk was not wrung when taken out of the liquor, answered that it would purge it too much from an impregnation so absolutely necessary for its taking the crimson dye.

Of the seventy-two pounds of silk already mentioned, thirty-two pounds is organzine, and the remaining woof. At Genoa it is the custom to allow two ounces of cochineal to twelve of organzine, if designed for the warp of damask furniture, and for the same silk an ounce and three-quarters of cochineal for twelve ounces of the woof, supposing it necessary to the beauty of the silk, that the warp should be fuller than the woof; and to bring the colour of the damask to still more perfection, they add to the organzine a quarter of an ounce of cochineal, that is, instead of two ounces they add two ounces and a quarter, adding no more to the woof than one ounce and three-quarters.

As the above thirty-two pounds of organzine should be of the finest colour, they allow two ounces and a quarter of cochineal to every pound of silk, so that upon the whole they use one hundred and forty-two ounces of cochineal, or eleven pounds ten ounces, Genoa weight, namely, thirty two pounds of organzine to two ounces and a quarter of cochineal, making seventy-two ounces; forty pounds of woof to one ounce and three-quarters, making seventy ounces — total, 142 ounces.

In order to dye this seventy-two pounds of silk, alumed as above, they make use of an oval copper containing, when full, two hundred quarts of water; they fill this copper two-thirds full of clean fountain water, adding afterwards the following drugs pounded and sifted. Two ounces of tartar, two ounces of saffranum, and two pounds and a half of the Levant galls.

They wait till the drugs have boiled two minutes in this liquor; after which they add the eleven pounds ten ounces of cochineal finely powdered and sifted; and whilst one of the workmen by degrees makes it sink to the bottom, another keeps violently stirring the liquor with a stick to promote the solution.

This done, they fill the vessel with clean water to about a foot of the edge, immediately afterwards dipping the thirty-two pounds of organzine divided on fourteen rods. They let it remain till the vessel, which they fill with clean water, and under which they put a large fire, is ready to boil; they then, to make the silk take the colour more evenly, raise the rods without ceasing, one after another, that each may alternately reach the bottom of the copper, which being but two-thirds full, the upper part of the silk would else remain out of the liquor, the rods being supported on the edge of the copper.

When the liquor was ready to boil, the forty pounds of woof, divided on eighteen rods, were dipped, they still continuing to raise the rods, one after another for half an hour, both the organzine and the woof, that each may alternately reach the bottom, so that when the workman came to the last he returned to the first, and so on successively.

After the first half-hour they stopped for a quarter of an hour between every operation, the workmen still raising the rods from the first to last, five or six times repeated in the space of an hour and a half, all the time keeping a good fire under the copper. The organzine was then steeped in this liquor two hours and a quarter, and the woof only two hours. The fire was then taken from under the copper, and the workman taking out one dip of the organzine and another of the woof, he wrung and dried them as much as he could to see if the colour was what he wished; if not sufficiently deep for the purpose, he let them both remain in the liquor something less than half an hour whilst the liquor was growing cold. He then took out all the silk, wrung it on the peg, then washed it several times in clean water, changing the water every time. This done, he wrung it again on the pegs, and so finished the operation.

It must be observed with regard to the organzine and woof, that though dyed in the same liquor they were not, however, of the same shade at the conclusion of the operation; the organzine was deeper, having been a quarter of an hour longer in the cochineal liquor, during which time it was impregnated with the more subtle colouring particles of the cochineal.

At Genoa it is not the custom to wash the silk out of the cochineal with soap water; on the contrary, they are persuaded that this practice dulls the brightness of the colour, and that the water, both for the cochineal liquor and for wash-

ing afterwards, should be the finest spring water; for they remark that the crimson dyed in summer with cistern water is by no means so bright as the crimsons dyed at other seasons when the fountains are full.

According to the dyers of Genoa there is a kind of cochineal which, though apparently beautiful, is not so in effect; that in using this cochineal it is necessary to alum the silk as much as possible, and to add to it more tartar than before mentioned. It is, however, impossible to give any certain rules concerning this matter; the dyer himself will judge of the quality of the cochineal fit for use. He should, however, use the best; for were it even a fact that the inferior kind, with the assistance of a greater quantity of alum and tartar, gives a colour equal to the best, the silk thus weakened by alum would necessarily be always less perfect. The Genoese manufacturers are so well convinced of this that they themselves furnish their dyers with cochineal in proportion to the silk given to be dyed.

Violet Crimson of Italy

The silk being alumed as for red crimson, take it out of the aluming and dye it with cochineal. For this purpose, dissolve two ounces of gum arabic in the copper; for every pound of silk two ounces of cochineal, a third of an ounce of agaric, and as much turmeric. Mix and pour them into your copper; when they begin to boil, and that the gum is perfectly dissolved, arrange your silk on the rods, immerge in the copper; let it boil for two hours, and it is then dyed. Let it grow cold, wash, and wring it on the peg. Wash it afterwards lightly. To make it violet, plunge it into the blue vat till it has taken a fine violet. Wash it in clear fountain water, wring it, and dry it in the shade, opening and spreading well.

Half-Violet

For one pound of silk take a pound and a half of archil, and mix it well in the liquor; make it boil for a quarter of an hour; dip the silk quickly; let it cool; wash at the river, and you will have a fine half-violet or lilac, more or less full.

Genoa Black for Velvets

The silk should boil for four hours with a quarter of its weight of white Marseilles soap, and be well washed. Boil in a copper with five hundred quarts of water, seven pounds of gall. Leave the galls to settle; draw off the clear, and having thrown away the grounds, return the gall water into the copper. Plunge into the middle of it a pierced pot containing seven pounds of gum senegal, seven pounds of Roman vitriol or copperas, and seven pounds of the cleanest iron filings. The liquor having dissolved these drugs, extinguish the fire, and leave it to ferment eight hours. Then heat it again, and when ready to boil, put again the same cullender into the same copper, and having made six parcels, each composed of the sixteenth part of the gum, copperas, and filings intended for the black liquor, in the proportion of one pound of each to every ten pounds of silk, dissolve in the cullender this sixteenth part of the whole. The fire is then taken away, and having thrown ten quarts of cold water into the liquor, to make it no more than hot enough to bear your hand in it, put your silks on the rods, plunge them into the liquor, where let them remain about ten minutes. Return the hanks four times, and afterwards wring them on the peg over the copper.

Fresh silk may be dipped in the same liquor, proceeding in the same manner. Begin first with the woof, then dip

the pile, and when the liquor is almost cold, dip the warp, which is seldom more than a black grey.

The whole of the silk having been dipped in this first liquor, the copper is then reheated, putting it into the same cullender with another sixteenth of the gum, vitriol, and iron filings. When the liquor is cooled as before, dip the silk as in the first liquor, observing at this time to dip the pile first, then the woof, and always the warp last, repeating this process six times. While the silk remained wet the black was excellent, even when compared with that of Tours; but it became different when dry. At Tours they thought to add to the black liquor, small wine, aniseed, and other drugs; but they at last determined to send some of their black silks to Genoa. The following is M. Regni's opinion in writing concerning them:—

"The dyers of Genoa, being made acquainted with the process in dyeing the specimen submitted to their inspection, have no doubt but that the last instructions were exactly followed, and that the want of success was owing, 1st, to having used Levant galls, which have much more substance than those of Sicily and Romagna, and commonly used at Genoa; 2nd, that the black liquor could acquire perfection only by a fresh dose of the drugs of which it was composed; so that in new and future operations they have only to remember in galling of the silk to make use of the galls of Sicily or of Romagna, or if obliged to use the Levant, to allow but one-third of a pound for every pound of silk, instead of half a pound of the former. The dyers of Genoa immediately conceived the kind of gall they had used in France from M. Regni's report —that a pound of silk weighing twelve ounces had recovered in the galling what it had lost of its weight in the soaping, whereas it should recover only eleven ounces."

With regard to the black liquor, it wanted nothing more to make it complete than an additional fresh dose of gum,

iron-filings, and vitriol of each an equal quantity, which should be added in small doses till the silk had acquired a proper colour, remembering that these drugs should be added to the old liquor, there being no occasion to make a fresh, since the old acquires perfection in proportion as it is used. This Genoese having dipped the pattern six times in his black dye, the black became much finer. The same dyer, a man enriched by his profession, writes that absolutely no other drug should enter into the composition of the black liquor than those mentioned in the last instructions preceding this, and that the wine and aniseed can be of no use but to spoil the black liquor.

In consequence of this letter they afterwards dyed very good black at Tours. The following process was practised in the manufactory of the late M. Hardion. For every hundred pounds of silk they boil during an hour twenty pounds of Aleppo galls powdered, in a sufficient quantity of water; the liquor is then suffered to subside, and when the nutgalls fall to the bottom they are taken out. They afterwards add two pounds and a half of English vitriol, twelve pounds of iron filings, and twenty pounds of native gum, either plumb or cherry, etc., which is put into a kind of pot with two handles and full of holes; this cullender is suspended in the copper, so as not to fall to the bottom. The gum is left to dissolve for an hour, stirring it lightly from time to time with a stick. If after an hour the gum remains in the pot, it shows that the liquor is sufficiently saturated; if, on the contrary, all the gum is dissolved, they add three or four pounds more. The cullender remains continually suspended in the liquor, except when they want to dye, and is immediately afterwards replaced. During all these preparations the copper is kept hot, but not boiling. The galling is done with one-third Aleppo galls. The silk is left in it for six hours, then for twelve, and the remainder of the process *secundum Artem.*

PART III

THE ART OF DYEING COTTON AND LINEN THREAD

OF DYEING IN GENERAL

Dyeing is the art of developing and extracting the coloured particles of any substance whatever, and of uniting them afterwards to stuffs, so as apparently to constitute but one body.

The object of dyeing is colour, as it is also the mechanical part of painting, differing only in the mode of operation. The operation of both arts is expressed by the word *colouring,* a term authorised by custom, however improper; for neither the painter nor the dyer do actually colour substances. To do this they must totally alter the configuration of their pores, which gives them the property of reflecting and absorbing in different degrees the rays of light by which their different colours are produced. The dyer indeed may enlarge the pores, and thereby produce white, in giving admission to a greater number of luminous rays; but quite otherwise in dyeing, since by filling the pores he prevents the admission of those rays; and by filling them with coloured bodies, it does not follow that he produces colours; but on the contrary, that these colours are pre-existing in the substances employed.

Some philosophers admit of only three primitive colours,

yellow, red, and blue. Black and white, properly speaking, are indeed no colours, white being nothing more than the reflection of all the rays of light, and black only a privation of light. Nevertheless, as black and white bodies exist in nature, as it would be a very desirable thing to discover any black drug capable of producing this colour permanently, and as whitening is an operation which in some respects belong to dyeing and is necessary to the dyer, I presume I may be justified in distinguishing relative to this art, five primitive or fundamental colours, which, combined *ad infinitum*, may produce all possible shades.

Just as paintings in water-colours, which easily fade, are distinguished from those in oil, which are permanent, in like manner the dyers distinguish the great from the lesser dye. But this last does not consist, as some imagine, in depositing extraneous substances on the surface of bodies only, or within pores not sufficiently capacious for their reception. Substances of this nature have never been employed even in the lesser dye, as washing alone would carry them off.

The lesser dye consists in introducing into the pores of the substance to be dyed, matters whose particles are too much dilated for the capacity of the pores, and which are deprived of the gluten necessary for their retention; or if retained, are of a nature easily altered by the action of the air, which changes their texture, and consequently their mode of reflection.

The great or good dye consists in introducing into the pores of the substance to be dyed, certain colouring particles, which by the essence and combination of their principles are affected neither by the air nor sun, and in retaining them either by means of a gluten or by attraction.

There exist therefore several degrees of good dye, according to the different nature of the mastics produced in the operation of dyeing. There are good dyes for wool and silk, and others

for cotton and thread; some resisting only the action of acids, and other of fixed alkali. The first are proper for wool and silk, because these substances are not soaped; the latter necessary for thread and cotton.

From this definition of the good dye it evidently depends on a variety of concurring circumstances, which require particular investigation before we proceed to an explanation of our theory. I shall therefore, *first*, treat of the different substances commonly dyed; *secondly*, of the preparation given for dyeing; *thirdly*, of the various substances generally employed in the art; and *fourthly*, of the astringents introduced into stuffs previous to their being dyed.

I shall omit any mention of the lesser dye, because it is already sufficiently explained by M. Hellot in his treatise on the art of dyeing wool.

Inquiry concerning Wool, Silk, Cotton, and Flax

The substances generally dyed are wool, silk, cotton, and thread of flax. These substances being of a different texture, and their pores also different as well in size as in form, must necessarily be different in their aptitude for receiving and retaining of colouring particles.

Wool was probably the first substance that men undertook to dye, whether in the fleece whilst yet they wore the skins of animals, or whether in worsted after the art of spinning was invented. Silk and cotton were not known till some time afterwards; and the dyeing of flax was a new invention in the time of Pliny.

Of Wool

Wool is composed of an infinite number of fibres, which, like hairs, are only tubes containing a medullary substance.

These tubes are themselves sieves throughout their length, with an infinity of lateral pores. They are more or less curled in proportion to the greater or lesser quantity of these pores; which may be easily conceived, because the more interruptions in the continuity of a body, the more flexible it will be. The fibres of the wool being curled, must therefore have many pores, consequently great room for the extraneous substances which may not be only lodged in the exterior pores, but even penetrate into the whole extent of the tubes after the medullary substance had been expelled.

It is not therefore to be wondered at if wool, being of all substances that are made into stuffs the most porous, should be the most easy to dye, and imbibe the greatest quantity of colour.

Of Silk

Silk is a glutinous matter formed in the body of the worm, which hardens in the air while the animal is spinning. We may rationally conjecture that this liquor originally proceeds from the mucilage of the mulberry leaf, which in the body of the worm, by its combination with volatile alkali, becomes an animal gluten; and that this gluten acquires consistence in the air, in consequence of the evaporation of a thin oil and a part of this volatile alkali.

We have an example of this phenomenon in the drops found on the leaves of the *Roraire* (*Ros folis*), which being touched whilst the sun shines on it, will draw into white and very fine threads. The consolidation of this gluten is soon promoted in the silk by a yellow substance with which the animal impregnates its thread, which seems to be a concrete oil something of the nature of wax. Silk thread, therefore, is nothing more than a continued series of the moleculæ of this indurated gluten; but as in this desiccation these moleculæ will remain at unequal

distances, there will necessarily be inequalities, and consequently pores in the thread. Besides, all bodies being an assemblage of particles joined together either by combination or aggregation, their existence necessarily suppose pores formed by the interstices between their unequal surfaces. Even metals, however compact, are porous; but their pores are too small to be visible. Silk, in like manner, having pores only on its surface, and the interior part of the thread no concavity, as in wool, it follows that silk can admit no particles into its pores but such as are extremely subtle, and in very small quantities; that even the particles admitted require a stronger mastic than in wool, since they are only superficial, and incapable of penetrating.

Silk should therefore be, and really is, very difficult to dye in the permanent dye: it requires more dye, because as the pores are only capable of containing the finer particles, the overplus must be entirely lost. One ounce of cochineal is sufficient to dye one pound of wool; but it requires two ounces and a half to give the same shade to one pound of silk. In short, for this reason no colour is so permanent in silk as in wool.

Of Cotton

Cotton is a threadbare substance enveloping the grain of the cotton tree: it is not formed, as some people imagine, by the extravasation of the nourishing juice of the plant: were it so, it would vary both in size and form. It is truly a vegetation produced on the outside of the grain whose juice contributes to its nourishment and growth; and as no vegetable substance can receive a juice without vessels proper for its circulation, it necessarily follows that the fibres of the cotton are hollow within, in the same manner as those of the wool; but being a great deal finer, must be more difficult to dye,

because incapable of admitting such gross particles. It has also exterior and lateral pores like those of wool, communicating with the longitudinal tubes, which are also supplied with a kind of medullary oil, proceeding from the grain, which is of an unctuous nature. It is essentially necessary to expel this oil previous to dyeing, or else so far from penetrating, the dye would be extremely superficial. The existence of this medullary oil is evident from the difficulty with which cotton absorbs when plunged into water, and the facility with which it soaks when perfectly cleaned; and that if held up to the light in its natural state it appears opaque, but after cleansing, perfectly transparent.

Of Flax

Stalks of all plants are composed of three parts, namely, the medullary and sometimes woody part, the bark, and the epidermis; they represent in vegetables something like what forms the bones in animals, that is to say, the marrow, the substance of the bones, and the periosteum.

When the pith grows dry and becomes woody, it then adheres more or less to the rind, by means of a mucilage more or less tenacious, which is continually furnished by the exudation of the sap through the pores; so it is with the stalks of flax, hops, nettles, and many other plants, especially of the chestnut kind, from which it is possible to procure thread.

As the rind is an assemblage of fibres glued together by this mucilage, and covered with an epidermis formed by the same mucilage, which penetrating between each fibre, hardens in the air, the only method of obtaining thread from these plants is by dissolving this mucilage by which the fibres are glued to the wood and to each other.

This soaking may be performed in several ways, either by macerating the stalks in water or by putting them on the

grass and exposing them to the dew for a certain time. The last is the safest operation for preserving the strength of the thread, provided there be no great abundance of rain ; but it is more tedious and liable to accidents. Whatever may be the method, there is no fixing any certain time for this soaking, as it must depend on the adherence of the mucilage, the nature of the different plants, their degree of maturity, the quality of the soil, of the water, and the temperature of the air during the time of soaking.

As upon this operation depends the goodness and beauty of the thread, it is essentially necessary that it should be superintended by a man of intelligence, and a competent judge of the precise time when the mucilage is dissolved, for were this time to pass, the fibres, being naked, would weaken and rot. This soaking produces a fermentation truly acid, tending to putrefaction if not stopped in proper time. It therefore demands a knowledge that can only be acquired by practice ; for this reason the farmers and cultivators of flax who prepared it themselves, so seldom succeeded in having fine flax, that several of them discouraged and abandoned the cultivation. In Holland and in Flanders, and in all places remarkable for fine thread, this preparation is considered as a particular branch of trade. The culture of the plant is left to the farmer, who, when it is ripe, gives it to those by whom it is prepared.

The stalks of the plant being well soaked and dried, the wood but slightly adheres to the bark, from which it is detached by means of a *broie,* or stripped off in ribbands. The bark, though thus disengaged from the wood, is by no means yet discharged from its mucilage. This mucilage is in two different states ; first, that by which the fibres of the rind are gummed to each other and to the wood, which is dry and reduced to dust ; and secondly, that forming the epidermis,

which, when dried and hardened by the sun, resembles horn, like all mucilages when baked and dried. The first portion of this mucilage flies off in dust when the flax is beat, rubbed in the hand, or ground in the mills for the purpose: the fibres thus detached from each other are divided into threads, numerous in proportion to their fineness. Nothing then remains on the surface of each fibre but the hardened and tenacious gluten, by which it is prevented from appearing white; nor can the thread be whitened till this be destroyed, which operation is called bleaching, and of which I shall speak hereafter.

It may be presumed that the fibres of thread are porous; but that their pores are smaller than the pores of other substances commonly dyed. Their detached and separate fibres bear some resemblance to silk respecting their continuity, only they are more dry and compact; thread is therefore more difficult to dye, at least in the good dye. It easily takes the dye of logwood, Brazil, archil, carthamus, and in general of all substances whose particles are sufficiently minute to enter their pores; but unfortunately these substances give only false dyes. With regard to the good dye, I am of opinion it can only be accomplished by introducing the dye into the interstices of the fibres which compose the thread when spun, which interstices form so many artificial pores. We know at least that twisted thread is dyed with most ease, probably because the interstices are more numerous.

Conclusions from the Examination of Substances commonly Dyed

The examination of these four substances prove that their aptitude for receiving the dyes may be more or less attributed to their textures. Thus, without any supposition relative to the different homogeneity or affinity between the animal

and vegetable substances and the colouring particles, it may be easily conceived why those giving scarlet to wool do not produce the same colour on silk, nor give any to cotton. They produce on silk only the colour of lees of wine, very dull; because the particles of the cochineal form a lacquer with the calx of tin diffused in the dyeing liquor. The pores of the wool are large enough for their reception; but those of the silk being too minute, are incapable of admitting this gross lacquer. They admit only the dead particles of the cochineal, which are more subtle than those of the lacquer, because more simple, but whose colour is almost entirely absorbed by the calx of the tin. Cotton, in its natural state, admits of nothing within its pores; but, like silk, when properly cleansed, and for the same reason, it takes a lees of wine colour. With regard to the kermes and madder, silk, when prepared as it ought to be, readily imbibes their colour; of this I am well assured by repeated experiments, whatever may have been urged to the contrary. It is besides very certain that before the discovery of cochineal, silk was always dyed with kermes, and it was then called scarlet silk.

To the different textures of the substances to be dyed may be also attributed the different shades they take in those dyes capable of penetrating their pores, though dyed in the same manner. This remark holds good even with regard to stuffs differently manufactured, though of the same kind: different fabrication necessarily contracting the pores of the stuff in a greater or less degree, makes them receive more or less of the colouring drug. This contraction is the reason why scarlet cloth when cut appears interiorly white, the colouring atoms being too large to penetrate; but this never happens in those colours for which the cloth is previously alumed.

Independent of this reasoning, the different positions and

delicacy of the fibres of the stuff cause a difference not only in the shades, but also in the brightness of colour, in proportion to the greater or less reflection of the rays of light.

Of Bleaching

Whitening of thread, scouring of wool, and ungumming of silk, is nothing more than the same operation differently performed for these different substances, but intended for the same purpose, viz. to divest them of the unctuous and extraneous matter which prevents the colours from adhering, and tarnishes their brightness. The colour white being the effect of the reflection of all the rays of light, and all other colours being produced by the refraction of the same rays of light, it follows that bodies are incapable of being whitened till divested of this inherent substance, which obstructing their pores prevents the reflection of the light. Alkaline salts act most powerfully on this substance, because it is of an oily nature; alkalies are generally used either in a pure or in a soapy state. Acids are nevertheless used for the same purpose in the whitening thread, and to divest it of a substance that will not yield to alkalies.

Wool is commonly cleansed with fermented urine, which forming a soap with the unctuous matter, easily carries it off.

In order to divest silk of its natural yellow, it is boiled in soap and water. Fixed alkalies would do as well, but these are not used, because they naturally corrode all animal substances. Nevertheless as the lustre of our European silk ungummed with soap is remarkably inferior to the Chinese, it was proposed to substitute the salt of kali. We do not however hear that it has been ever adopted in any of the manufactories.

If it be supposed that the inferior qualities of our silk be

owing to the oil in the soap, a lixivium of the kelp of Alicant might be substituted with some advantage, because the phlogiston it contains would weaken the operation of the salt. This lixivium, I should imagine, would be preferable to the soda proposed to the academy at Lyons by M. Rigaut of St. Quintin, that salt having no advantage over other fixed alkalies, since in crystalising it loses its phlogiston.

It was formerly the custom amongst the ancients to cleanse their wool with a plant which might perhaps be advantageously used in the ungumming of silk. This plant is the *Struthion* of the Greeks, called by Pliny, *Radicula* ; the root of this plant, says he, has the virtue (*Tingentibus Radicula lanas preparat, quam Struthion de Graiis vocari diximus* (P. L. 24, sect. 58). *Radicula Lavandis lanis succum habet : mirum quantum conferens candori, molitieique* (P. L. 19, sect. 18)) of giving softness to wool, and the most astonishing whiteness : it grows in cultivated ground, also naturally in stony and uncultivated places. It has large and extended roots, which, when used for the cleansing of wool, are pounded. Dioscorides (L. 2, ch. 193), speaking of this plant, calls it the same which is sold in the shops by the name of soap-wort, because used instead of soap, and that it answers as well for taking spots out of stuffs and for cleansing wool of its natural fat. P. Hardouin says it is called by some the fulling herb, because used in fulling of cloth. Linnæus (*Syst. Nat.* 2, p. 1028) calls it *Gyspsophila Struthion*, and we are told that the peasants of the province of La Mancha in Spain also used it in the nature of soap. It is certainly the same, at least of the same genus of a plant common in Calabria, known by the name of Lanaria, the root of which is there used for cleansing of wool.

Our soap-wort is a kind of lychnis growing near rivers, ponds, in woods and sand. It has a long, reddish, fibrous, and acrid root, broad leaves, like those of a plantain, having

a nitrous taste. It is cultivated in gardens, is very bitter and very astringent. It takes spots out of clothes like soap.

We know of several plants that might be used for the same purpose; first, pellitory, growing abundantly in old walls and ruins. The peasants in several places make use of the leaves for cleaning of glass. Secondly, the *pied de veau maculé*, the stalks and leaves of which the women of Poitou macerate in water, changing the water every day: the grounds, when pounded, they use instead of soap for washing of linen.

There is besides a kind of *liseron* (*Convolvulus marinus*) growing on the borders of the sea. The substance of the leaf is fat, and has a salt taste; its flowers white and bell-shaped, a species of soldanella. This may be also used in the same manner, as may all the kalis in general, especially when fresh gathered.

Such minute inquiries may perhaps be deemed trifling; some will imagine that the use of these plants having been at a time when soap was but little known, need not be much regretted at present, when soap may be easily procured. I agree with them so far, that it may be always more convenient for individuals to make use of soap; but in manufactories, where the advantage of one above another consists in the highest perfection and greatest economy, the case is different. They would experience both in the use of these plants. It would require only to have a corner of ground near at hand planted with one of those plants, from which a part may be gathered as occasion required; and as it is the oil of soap which tarnishes the silk, this inconvenience would be avoided by using the natural soap of vegetables, which must be still more innocent than even the best artificial soap, because the combinations of nature are always more perfect than those of art.

As the effect of fixed alkali is much less violent on vegetable than on animal substances, it is used for the former simply, and even sometimes quickened by lime. Nevertheless the lixivium is diluted in a quantity of water sufficient to weaken and prevent them from injuring cotton.

The whitening of linen thread and flax is in like manner performed with fixed alkali; but as the substance adhering to their fibres has a vast deal more consistence than that adhering to wool, cotton, or silk, the bleaching of these can only be accomplished by degrees, and requires much patience. Very caustic lixiviums are sometimes used by way of accelerating: they indeed whiten more speedily, but it is at the expense of the thread itself, these lixiviums attacking the substance at the same time that they act on the tarnishing matter. You succeed better and more certainly by alternately soaking the thread in weak lixiviums, and by exposing it to the heat of the sun, and to the dew, and even watering it from time to time during the day. It is impossible to determine how often this operation should be repeated, as it depends on the quality of the ground which produced the lime or hemp, of its maturity, and on the manner of soaking, which may be infinitely varied.

There is a plant that might perhaps be used with advantage, as the ancients employed it successively in whitening their linen. Pliny calls it *Papaver sylvestre, a quibusdam heraclion vocatum, ab aliis Aphron.* It is the Peplos, or round spurge. [*The author is certainly mistaken in supposing Pliny's* Papaver *(poppy) to be a species of* Euphorbia *or spurge.*] We have some reason to suppose that the small spurge growing in great abundance in Provence and Languedoc, the large field spurge, and marsh *Tithymale,* otherwise called black or bastard turbith, which grows on the sandy banks of rivers and ponds, and is also cultivated with success, might serve for the same purpose. All these plants are impregnated with abundance of a milky,

acrid, and caustic juice, which might supply the place of alkaline lixivia.

The process of bleaching is nearly the same in all countries; it differs only in the time and mode of operation. This difference is not to be wondered at, since it is founded on the nature of the matter to be expelled in whitening. Flax, hemp, and all other vegetable substances capable of producing thread, are impregnated with a considerable quantity of sweet oil, not volatile, mixed with the mucilage of the plant. Fixed alkalies combined with the oily particles, form together a soap, the solution of which in water would be prevented by the mucilage forming a mastic with the oil; now this mastic can only be detached from the thread by exposing it to the heat of the sun, by which this alkali is volatilised. But the thread, though washed and several times dried, is not yet sufficiently whitened. I have already said that one portion of the mucilage which forms the epidermis of the stalks, having been baked by the heat of the sun, is so extremely hard that lixiviums cannot affect it. Besides, the soapy matter, which can neither be volatilised nor carried off by alternately watering and drying the thread, must by the volatilisation of the alkali be transformed into an absorbent earth. Many bleachers use lime, and by frequently sprinkling and exposing to the sun, load the thread with this substance; it is therefore necessary to carry it off, which cannot be effected by washing the thread, because this earth will not dissolve in water. Acids only are capable of destroying it; which with the absorbent earth compose a neutral salt, soluble in water, and consequently may be removed by washing the thread well. The acids commonly used are sour milk, or an infusion of bran or flour of rye kept till it becomes sour. Some imagine that the sour whey makes the thread yellow, caused by the oleaginous particles of the milk, and therefore prefer the juice of sorrel. Those who understand their own interest have recourse to the

oil of vitriol; this, though diluted in a great quantity of water, has the property of completing the whitening of thread. In this state it cannot possibly injure the thread in any respect; it detaches the chaffy particles still adhering to the thread for want of sufficient maceration, and also the earth.

Preparations for Stuffs to be Dyed

Considering the state of the arts among the ancients, and comparing them with what they are at present, we frequently find that they were ignorant of nothing of what we either know or do. This observation of M. Le Comte de Caylus is particularly true with regard to dyeing, as the practice of our workmen is nearly the same as that of the Greeks, and that we have even lost some parts of their art. Probably an attentive consideration of the few hints they have left us may lead to the perfection of the art of dyeing.

The Greeks distinguished three operations in dyeing; the first, which they called *αραίωσις*, consisted in opening and dilating the pores of the subject in order to dispose it for imbibing the colour. The second, which they called *βαφὴ*, was the dye itself, that is to say, the dipping into the dyeing liquor. The third and last, *χατοχη*, consisted in fixing the colours by means of certain drugs. They also called this operation *σύψις* and the ingredient employed for this purpose *συμμα*, which proves that it had a styptic and astringent quality.

Their first operation is represented in the art of cleansing by our dyers, who actually open and dilate the pores of the subject to be dyed. We might perhaps compare the latter to our aluming, since alum is an astringent, and as Tournefort tells us that at Gora they used a species of *garou* in the yellow

dye, adding to the infusion of this plant a little alum, called by the people of that country συψη. I nevertheless believe that the operation indicated by the terms κατεχσας and συφεσαι was independent of aluming, and that it is more analogous to that custom of our dyers in using for some colours sumach, agaric, galls, and other astringents. Their action indeed consists in crisping and contracting the fibres of the subject to which they are applied; hence it follows that the solid particles of these fibres are approximated, and the force of their cohesion considerably augmented. The substance of the body thus acted upon must necessarily become more firm and compact, and therefore more capable of resisting the action of the air and of the salts, by which those salts, already enclosed, might be discomposed.

This operation was also practised in the time of the Romans, by whom it was called *colorem alligare.* For this purpose their dyers used a species of fucus, to which Pliny ascribes the property of fixing the colours on wool so effectually as never to be removed. Many of our fucuses are abundantly supplied with phlogiston, the combination of which, with the salts, might produce this effect. The fucus growing on the coast of England, analysed by M. Home, seems to be of this nature. It contains, says this chemist, more salt than any plant I know; but it contains also another substance (doubtless phlogiston) that makes it incapable of whitening, especially fine linen, though already tolerably white. Bleachers have remarked that it communicates to linen a yellow colour. The same author observes, that having dried, burnt, and kept this fucus in fusion for more than two hours, he obtained from the quantity burnt three ounces and a half of ashes, which when washed in three pints of cold water, produced by evaporation five drachms and forty-six grains of crystallised salt, containing marine salt, sulphur, and alkali. The liquor being

entirely evaporated, there remained four drachms and a half of a yellow salt, which appeared to be a very strong alkali. He made an infusion of the same ashes in warm water, boiled it, and during the evaporation, a piece of white linen which he had put into it for half an hour, contracted a colour that he could never afterwards remove. This liquor, when evaporated, gave him four drachms of a black bitter salt. From these results he concluded that these ashes contained something less than one-fourth of sulphur (*phlogiston united to marine salt, and not sulphur*), the same quantity of marine salt, about one-fourth of alkaline salt, and a little more than one-fourth of earth.

From these observations we may conclude, first, that the burning of this seaweed might be attended with greater advantage, and which may doubtless be found on the coasts of Brittany and Normandy. These ashes are sold in England for one pound sterling the thousand weight. Secondly, that the fixed colour with which the phlogiston contained in these ashes penetrates the linen, might be a better and more efficacious preparation for dyeing than the nutgalls used in the black dye for wool and silk, and for dyeing of cotton, the phlogiston contained in the nutgalls being less adhesive because of its oily nature, and I make no doubt that it will be almost universally allowed that this fucus is the true alga which Pliny asserts to be so useful in the fixing of dyes.

Astringents

Under the denomination of astringents, I comprehend all salts that are dissolved in water for the impregnation of stuffs, which solutions the dyers call boilings. These are principally alum, lime, marine salt, nitre, sal-ammoniac, tartar, fixed and volatile alkalies, and the various metallic salts.

The utility of lime in dyeing has been long known, though we are still ignorant of its nature. It was used by dyers in Pliny's time, under the name of *Lapis Phrygius* (see Pliny, L. 36, cap. 19, sect. 36, and Diosc. L. 5, cap. 41). It is most commonly used in the pastel and indigo vats intended for dyeing cold; but it extends to many other operations in the hands of those who are acquainted with its effects. It seems destined by the author of nature for binding and uniting together two of the greatest opposites, salts and earth. Fire makes it soluble in water, and therefore easily used; but it again becomes indissoluble by the contact and influence of the air. These properties render it capable of forming, when united to other matter, an unalterable cement. We know several mixtures of this nature of which lime is the basis, and that in consequence of these properties it confirms the solidity of many colours.

If lime has the power of fixing colours, alum has, besides that, the property of attracting the colouring particles. This property was not unknown to the ancients (see Pliny, L. 35, sect. 15), who used alum in their dyeing. Whether we are indebted to chance for the discovery, or whether to rational inquiry, which having found in alum or in the earth of alum the property of imbibing colouring principles with more avidity than calcareous earth, I am ignorant. It is, however, certain that what they called *Creta argentaria, salunisia, anularia*, were species of marl of the nature of argillaceous earth, such as the earth of alum. These substances were coloured with different matters, as we find by Pliny and Vitruvius, by steeping them in coloured infusions, with which they became much sooner saturated that wool (see Pliny). We may presume that this observation was the first step towards perfection in the art, as it put them upon seeking the means of introducing the particles of this earth into the pores of the wool,

and thereby disposing it to imbibe the colour more readily. Alum, the acid of which holds this earth in solution, furnished the means of affecting it. They distinguish two kinds, roche and Roman alum. The first being the cheapest, is always used for blues and the colours inclining to black, but this being liable to contain some particles of iron, the Roman alum is preferred for lively colours, because it contains nothing that can tarnish their brightness. The whiteness of its earth renders the colours more bright, and its tenacity, produced by a certain unctuosity with which it is combined, more solid. The plastic quality of this earth makes it take the form of the pores of the subject to be dyed: a greater permanency of colour must necessarily ensue.

They also in dyeing use nitre, marine salt, sal-ammoniac, and tartar, not indeed as astringents, but as alterants. The three first certainly sadden the reds, giving them a crimson tinge; the tartar and other acids produce an effect quite contrary; they enliven by inclining the colour to orange.

Neutral salts, with a metallic basis, serve less to produce solidity than to give strength to the colour, for it is known that colouring substances vary their shade according to the nature of the metallic earths by which they are attracted. The earth of alum possesses this quality for no other reason perhaps than because of its metallic nature. Two amongst the neutral salts having a metallic basis, unite with an astringent quality that of an alterant, and are most commonly used; these are copperas or vitriol of Mars, and blue vitriol or vitriol of copper; they seem to owe this to their astringency.

Theory of Dyeing Stuffs prepared with Alum

M. Macquer observes (*Mem. de l'Acad. des Sciences,* 1762) that as soon as the earth of alum is moistened, it greedily

imbibes all the oily, and consequently colouring, particles of the bodies in contact. This property indicates in this species of earth a strong disposition to combine with the principle of inflammability, and to retain it most forcibly. The earth of alum therefore possesses the property of attracting the colouring particles. The cause of this attraction we do not know; but since the effect is certain, let us confine ourselves to that consideration, regardless of the cause. Suffice it therefore, in our explanation of the theory of dyes wherein alum is used as an astringent, to explain the conditions necessary to the attraction of bodies. It is requisite, first, that the power of attraction be reciprocal in both bodies; secondly, that they should be placed at a distance from each other proportioned to their force of attraction; thirdly, that this force be superior to that with which one of the bodies is attracted by the fluid in which it is suspended.

It is therefore necessary for dyeing of stuffs that the dye should consist of corpuscles suspended in a liquid in such a manner that they may be separated by a substance which has a greater affinity than the water with these minute bodies. Earth of alum is this substance for the colouring particles in the good dye. There are colouring substances which the earth of alum does not attract, but which have still less affinity with water than those requiring the astringency of alum, so that they enter the pores of the stuffs without its assistance; but of this I shall speak hereafter. Concerning the colouring particles of the good dye, and which require the stuffs to be alumed, these particles fix to the earth of alum by the power of attraction, and at the same time the acid of the alum is softened by its combination with the principles of these particles, this acid having served merely as a vehicle for distributing equally into all the pores of the stuff that earth which it held in a state of the greatest possible divisibility.

In my examination of various colouring substances I developed this theory, which I hope to demonstrate, and which I think preferable to the systems of my predecessors on this subject. Notwithstanding the deference due to their opinion in every respect, I could never conceive that salts, however hard, such as vitriolated or crude tartar, could maintain their stability in the pores of the stuff; however small the quantity soluble in water, it would be difficult to prevent washing from carrying off a great portion of the salt, and consequently of the colour, or to prevent it from being injured by the decomposition of these salts; whereas fixed earth, such as that of lime and alum, which form its nature, obstinately retaining the phlogistic principles of all colours, must necessarily produce colours incapable of being destroyed but by the strongest acids.

Of Colouring Substances

No one is ignorant at present that colours depend on phlogiston; that from its different modification and various mixtures with oils, earths, and salts, and from the quality and quantity of these three principles, results the diversity of colours. It is also known that by the simple addition of any salt to an oily, vegetable-colouring substance, you may change or totally expel its colour; because any salt, simple or compound, destroying by the laws of affinity the combination then subsisting, the rays of light are differently reflected. Substances the colour of which cannot be altered by any salt, are therefore most probably those where phlogiston is in perfect combination with the other principles. A perfect knowledge of this combination would doubtless guide us, by an analysis of the colouring substances for the good dye, to artificial compositions, in like manner as we make artificial cinnabar, for example, in consequence of our knowledge of the principles of native cinna-

bar; we should then have more hopes than we now have of bringing drugs yielding the false tinct to be equally durable with those of the good dye. But though we know, even to a certainty, the effects produced by salts on certain oils; that we can decompose some colouring substances and separate their principles, it remains to be known in what manner these principles are combined, and consequently we are reduced to the necessity of endeavouring to improve those given us by nature. Our want of knowledge in this particular should not be regretted, since the drugs for the good dye are such only, because they are incapable of decomposition, and that the end proposed in the fixing of colours is answered only by combining them with other principles in such a manner as to render a decomposition impossible.

The various colours existing in vegetable and animal substances are some of them visible in the body by which they are furnished, and others concealed and manifested only by the action of various salts. The manner of developing these colours constitutes a part of the art of dyeing; nevertheless dyers do not always take this trouble, whether because the composition be insufficient to make it worth while, or whether because the substances furnishing these colours are exotics.

The dyers therefore buy all their colours developed; chiefly the blue drug called indigo, that extracted from the *Ricinoides*, known by the name of tournsol; the red colour, produced by various species of lychnis, with which the archil paste is made, etc. The number of these colouring *fæculæ* might doubtless be considerably augmented. We shall mention by way of example the milky juice of the wild lettuce with prickly sides, and that of the sweet and thorny sow-thistle, which with a lixivium gives a fire or carnation colour, very lively but which soon degenerates into a fixed yellow. Secondly the juice of wild patience or dragon's blood, the crimson colour

of which turns to a blue that may be fixed. Thirdly, the common caterpillar of the white thorn, by means of a lixivium, gives a purple colour. Fourthly, the amber coloured *scolcpandrium* gives an azure colour tolerably fixed. Fifthly, the purple extracted in Sweden from the wild marjoram. Sixthly, several species of lychnis furnish yellow colours, etc. etc. I mention these substances for those only who, having leisure and curiosity to make these experiments, may find the means of extracting their colours with advantage. The arts can arrive at no perfection but by adding new discoveries to those that were made before us: *Nunquam inveniuntur, si contenti fuerimus inventis* (Sen. Ep. 33).

The concealed colours which the dyers are in the habit of extracting themselves, are the blue colour of woad, that extracted from logwood, the simple infusion of which is a dark purple, the red colour of the root of madder, that of the flowers of bastard saffron, etc.

Every colour necessarily supposes a solid body of which it is a modification. For water, which makes a principal part of the juices of roots, leaves, flowers, fruits of certain plants, of animal fluids, such as urine, blood, bile, etc., this water, I say, is in itself not susceptible of any colour, only inasmuch as it holds in a state of emulsion the colouring particles infinitely divided.

Pliny tell us that our ancient Gauls extracted from these juices the colours which the Romans sought for at the bottom of the sea, and in fact we find in this author the names of many plants which are no longer used in dyeing. A great number may also be found in botanical authors, ancient and modern. The perusal of these works excites the curiosity of those who are but little conversant in the principles of dyeing. Seduced by the beauty and brightness of the colours of these plants, they fancy they have made some discovery, and insert it in the

periodical journals without reflecting that these juices were discontinued in consequence of better knowledge, when our ancestors, enlightened by their intercourse with other nations, discovered substances imparting more solid dyes. Pliny observes with reason that the dye of these vegetables will not stand the washing (*Transalpina Gallia Herbi Tyrium atque conchylium tingii omnesq; alios colores—sed culpa, non ablui usu.*—Pl. L. 22, sect. 3). Their juices are in fact nothing more than a liquid coloured with essential oils, and converted into a kind of soap either by an alkali or a neutral salt. They are therefore incapable of giving more than the false dye, because these soapy compositions always retain their characteristic of solubility in water, for their colour is soon lost by the effect of the air, owing to the volatile principle of the essential oil. If even my hypothesis on the nature of these juices be rejected, the volatility of their colours will effectually prohibit their use, since neither alum nor any other matter can fix them.

We must not be surprised at it; but on seeing these colouring juices, one would be apt to say that the fluid itself was coloured, so exceedingly minute are the colouring particles therein suspended, and consequently so great their affinity with it. This affinity being superior to the force with which the colouring particles and the earth of alum mutually change each other, the attraction between them cannot take effect. Thus we see that the dyes extracted from these juices acquire no degree of stability by previously aluming the stuffs, because the earth of the alum remains colourless within the pores, together with the colouring particles, but without uniting with them; or if even the alum were coloured, water would immediately wash off the colouring particles.

I do not say that there is no possible method of rendering these drugs more permanent, for example, by introducing absorbent earths within the pores of the stuff, or by adding

acids to the colouring juices, which would decompose the soap and facilitate the union of the colouring particles with the earth. But it may happen that this decomposition would entirely destroy the colour or change it to another. Such experiments have been hitherto neglected in consequence of the facility of extracting the same colours from substances requiring less trouble, the uncertainty of success, and the little advantage that might result from such experiments.

Animals furnish but few of the colouring juices, and if they did, it is easy to perceive by an examination of the bile and blood that they would be no better than the vegetable juices just mentioned.

Since therefore neither vegetable juices nor animal fluids are capable of giving us permanent dyes, let us endeavour to obtain them from solid colouring substances, namely, from those animals who are endued with colour, or from such particles as had previously constituted some part of the texture of different plants. Thus with regard to ingredients for colouring, those used by the dyer are of the same nature as those used by the painter, differing only in the manner of operation, as it is sufficient for the painter if the colouring particles be deposited on the surface of his subject; but with regard to the dyer, they must be enclosed within the pores of his. They still resemble each other in their attention to preserve their colours from the injuries of the air, though by different means.

Painting has nevertheless great advantage over dyeing, which is deprived of many of the colouring substances used in the former, such as ultramarine, zaffre, cinnabar, the various species of ochre, and in general all the colours taken from the mineral kingdom. The colouring particles composing these bodies, minute as they seem, are nevertheless incapable of being attracted by the earth of alum, because they are naturally dry, and that alum attracts only unctuous matters; neither

could they be used more successfully without alum, because though introduced within the pores of the subject, they never would adhere on account of their dryness, but would escape with as much facility as they had entered.

Vegetable and animal substances of the good dye are such only because they are provided, notwithstanding their desiccation, with a tenacious gluten, produced by a mucilage in the one and by a glutinous matter in the other, combined with either a vegetable or animal oil. In the dyeing liquor these principles form a gluten which, in proportion as they are attracted by the alum, enter the pores of the subject, giving the particles the property of attaching themselves strongly to the alum which had previously entered the same pores, and forming together a real mastic. Now the earth of the alum entering these pores was, as I have already said, in the greatest degree of divisibility. The acid in the composition exerting its whole power on the gelatinous oil, and the mucilage forms a cement which is destroyed with difficulty in proportion to the nature of the different colouring particles; the atoms of the alum enlarged by this addition cannot escape from the pores into which they had been introduced. This cement is, I say, with difficulty destroyed, according to the nature of the different particles, because on the different principles of which those are composed, depends the degree of their stability, and chiefly on the quantity and quality of the oil which they contain. The difference occasioned by this necessarily makes a difference in the nature of the cement, which, as it is more or less strong, resists in a greater or less degree the action of the sun.

Of Cochineal and other Colouring Insects

Cochineal is an insect found in Mexico on a species of the fig-tree, called *Opuntia*. It is also found on many others,

and I have observed it particularly on a tree called *Ambrosia Peruviana*, which is cultivated in the king's gardens. But this yields only a reddish colour. We may therefore conclude that the scarlet of the cochineal is owing to the juice of the opuntia upon which the insect feeds, and whose principles combining with those of the animal, constitute together but one and the same substance. Animals being composed of oil, earth, and volatile alkali, the same principles are also extracted from the cochineal. [*I have myself extracted a pretty considerable quantity of oil from the cochineal, and still more from the kermes. Should anyone doubt concerning my operation, he need only apply to MM. Geoffry and Margraaff* (see *Mem. of the Acad. of Sciences*).] It is therefore easy to conceive why its colour is of the best dye, the stuffs being previously alumed. The volatile alkali of the cochineal renders the colour bright; the animal oil united to the solid and mucilaginous particles of the insect produce the first ingredients of a mastic which, being completed by the alum, preserves the colour from the influence of the air or sun. Hence the permanency of this colour, which, with regard to the crimson extracted from cochineal, is undoubted, because it is the natural colour of the insect; the greater therefore the deviation from this shade by alterants, the more it loses of its fixity.

As the colour depends on the shape or figure of the constituent particles of the colouring bodies, the shade may be varied by changing their figure; but the permanency of the colour is at the same time diminished, because it is impossible to produce this change without altering the principles to which they owe their permanency; this is the case with the cochineal. Acids and alkalies easily vary the shades of its colour.

These shades are saddened by volatile alkalies more than by any other, but these are seldom used on account of their price. Fixed alkalies also sadden, inclining them to purple

in proportion to the quantity used. These salts produce this effect because they are the natural solvents of animal substances, which, however, they are incapable of dissolving without combination, causing only a decomposition without the dissipation of any principle. This combination gives to the colouring particles a degree of density which they had not, incline them to black, occasioned by a greater refraction of the rays of light. Acids, on the contrary, and especially mineral acid, burn the oil and absorb the phlogiston, which is the principle of colours: by the violence of their action a part of the phlogiston and volatile alkali evaporates; the colouring matter becomes more rarefied, and reflecting a greater number of the rays of light, it necessarily acquires a colour nearly yellow, and even if more be added, quite yellow, which is of all colours the nearest to white or transparency.

It is not therefore the custom to use fixed alkali in the cochineal liquor when dying with this substance. It would make too great an alteration in its consistence, and, by mixing with the animal oil, form a soap that would render the colour miscible in water, consequently of the false tint; because not then capable of forming a mastic, the oil, occupied by the alkali, being no longer at liberty to combine with the earth of alum; it may, however, be used with advantage, and without danger, after the stuffs are dyed, because then the mastic being already formed, this menstruum has not sufficient power to destroy it, unless by putting too large a quantity.

The action of acids is more destructive than that of the alkalies; vitriolic acid, when formerly used in the cochineal liquor, saddened rather than brightened, because the common oil of vitriol, which is seldom free from some particles of iron, formed in the liquor a kind of Prussian blue, which, mixing with the red particles, communicated a purple tinge. [*Cochineal boiled with water in an iron vessel will have a purple*

tinge.] Spirit of nitre has been since used, but the action of this acid on oils and phlogiston being much stronger than the first, it was judged proper to give it a basis on which it might in part exhaust itself, and by communicating part of its phlogiston, render it less greedy of the cochineal.

This basis is tin: it was formerly dissolved by spirit of nitre, but since by *aquaregia*, which was found to dissolve it more completely. This solution is not used in the same manner as that of alum, by diluting in water and then dipping the stuffs previous to their being dyed. This preparation would not be sufficient, for by diluting in a great quantity of water, a part of the calx of tin would precipitate and be reduced to atoms larger than when dissolved in acids, especially if used alone and separate from the dye; the acid in that case not acting on the colour sufficiently to enliven it. Only part of this solution therefore is added to the cochineal liquor, and the acid then abandoning the tin and combining with the oil of the cochineal, the calx of the metal seizes the colouring particles whilst precipitating, and together, as M. Hellot observes, forms a kind of lacquer which insinuates into the pores of the stuff, and is there retained by a gluten given by the starch which was added to the dyeing liquor. From this explication it is easy to comprehend why the scarlet dye is much less solid than the crimson. The lacquer being much drier than the simple colouring particles of the cochineal, is, in this state, nearer to the nature of the mineral colours. The oil and the animal gluten, which in the crimson dye form with the earth of alum a mastic, are destroyed by the acid, and the starch then added is an insufficient substitute.

What I have here said of the cause of the fixity of cochineal after the stuffs have been previously alumed, applies equally to gum lac and kermes, the constituent parts of which are found by analysis to be the same. The kermes has even the

advantage of being composed of still finer particles, which more easily penetrate the pores of the stuff, as I have experienced in silk and cotton. It is well known that silk, on account of the smallness of its pores, takes up only a part of the cochineal, but from the kermes it extracts the whole of the colouring particles, which is also more fixed, probably because the shrub on which the insect is nourished communicates its astringency, or that it contains a greater quantity of oil. Cotton, into the pores of which cochineal cannot penetrate, may be dyed with kermes.

It is to be lamented that the use of kermes is abolished. It is supposed to be scarce, because it is used only in medicine; it is dearer than it ought to be owing to the small quantity collected. But if it were again brought into general use for dyeing, the price would be considerably reduced, as the shrub on which it feeds requires no cultivation.

Other insects were formerly used in dyeing, but these it is unnecessary to enumerate, as their principles are probably the same; they are no longer in use. About two years ago, in the *Gazette de France*, was announced a secret which consisted in extracting a red colour from a species of bug. This pretended discovery reminds me of an observation of Lister's, communicated about one hundred years ago to the Royal Society of London, concerning a red colour that might be obtained from a red insect with black spots, of the larger kind, which he calls, *Cimex ruber, maculis nigris distinctus, super folia Hyasciami frequens.* This bug is found in great quantity in the month of May on a species of henbane. Lister thinks it probable that this insect was nourished by the unctuous matter with which the leaves of the shrub were gummed, and which stuck to the hand when touched. He adds that towards the latter end of May, or rather earlier, the eggs of this insect were found adhering to the upper part of the leaves.

These eggs were of an oblong form and orange colour. In the body of the worm they appeared white, and continued of the same colour even after they were laid, though they generally acquired a darker colour when near being hatched. They produced these bugs which never became worms. These eggs, if broken on a bit of paper when mature, stained it, without requiring any kind of salt, the most beautiful scarlet or fire colour that could possibly be conceived.

These eggs will doubtless remind us of those discovered by M. Réaumur on the coast of Poictou, and in which he found the property of a most beautiful and permanent red colour. The account is to be met with in the *Memoirs of the Academy of Sciences for the year* 1711.

It were certainly right not to neglect the discoveries of naturalists, and it were also to be wished that these discoveries might give rise to decisive experiments. But how can we presume to hope this whilst we have the cochineal imported to us from foreign countries and at a great expense, notwithstanding that its dye is less permanent than our kermes. Man, naturally idle, sleeps in the midst of enjoyment, and is waked only by the calls of necessity. When, therefore, at some revolution we shall be prohibited from the use of cochineal, or when it becomes dear, we shall then have recourse to the eggs of M. Réaumur, or the henbane bugs, or rather resume the use of the kermes, of the dye of which we are so well assured, though too lightly abandoned. The invisible hand of Providence, who preserved the madder in our hedges, which we had ceased to cultivate, will preserve for our use the *Ilex aculeata* and the insect it nourishes.

Of Madder

There are several species of madder; that brought from Zealand, called in Latin, *Rubia tinctorum*, is the most in use.

The Romans, according to Pliny, called it *Erythrodamus*, which proves that it was known to give a red colour, and was much used by the Greeks. It was used in his time for dyeing wool and skins. The Italian madder was the most esteemed, particularly that grown in the environs of Rome, and in great quantities in all the provinces of the Roman Empire. They distinguished two sorts, one wild and the other cultivated; the last was sown in the same manner as peas. It was afterwards called *Verantia* or *Varantia*, probably on account of the permanency of its colour, whence originated the word *garance*. The use of this plant, as we perceive, was very ancient in Italy, since Pliny lived in the first century, and it is highly probable that it was equally known in Gaul, which was then under the dominion of the Romans. It is therefore contrary to all reason that the author of the *Nouveliste Economique and Literaire*, printed at the Hague, says that it is some centuries ago since it was brought from the Indies into Persia, from that country to Venice, and from thence by the way of France and Spain, into the united Provinces. It would be difficult to determine whether the species mentioned by Pliny be the same which we call *Rubia tinctorum*, especially as there are many kinds, and that the roots of several species of *gallium*, and in general of all the *rubiaciæ*, yield a red dye; the only difference is as they yield more or less.

Dioscorides, when speaking of this plant, gives the preference to that of Ravenna, and says that it was sown in the field amongst the olives. If this be the plant described by Ray [*Rubia sylvestari aspera, Ravennencis Zannoni*] after Zannoni, it appears to be a different genus from any we know. The root of this plant is slender, and about eighteen inches long; its rind is thick, and adhering to the interior part. It shoots several straight stalks, firm, round at the beginning, and of a dark colour, which soon take a square form and green

colour, a little higher at the place where the leaves are produced; these stalks are hollow, furrowed, and from space to space furnished with knots round which grow the leaves, disposed in whirls to the number of four, five, or six, an inch long, and two lines broad. Leaves are smooth at first, but afterwards become a little downy. Pedicles of the leaves brittle, and reddish underneath. Flowers composed of a green calix, with five leaves, and a corolla having five petals of the same colour. Stamina yellow; root much spreading; fibres capillary of a dark red colour; these fibres throw out yellow and transparent shoots, producing new plants. It is found near Ravenna in the Forest of Pines. This plant evidently differs from all our known madders. Some years ago I wrote to M. Ginanni, a patrician of Ravenna, to procure me some of the seed, with design to cultivate it in this country. I hoped that he would have obliged me, as he was a member of the society of Agriculture at Paris; but I received no answer.

There is another species of madder, different from our *Rubiaceas*, but common in the isle of Candia. Its flowers are in form of a spike. Botanists have therefore called it *Rubia spicata*.

In the Indies they make use of various kinds of rubiaceas in dyeing thread or cotton, such as the *Chat de Perse*, the *Morinda*, the *Hedyotis*, the *Rojoc*, the *Chaive*. We have imported the roots of this last, which has great similitude to our *Synanchine* or to the *Gallium flore albo*.

The East India Company some years ago imported a root which they called *Mongister*, of the size of a quill, equal throughout its length, about six feet or longer, in other respects resembling madder; they said it came from the West Indies. The root of *Gallium luteum*, observed by M. Geuttard on the coast of Poictou, exactly resembled it in form, length, and breadth, so that it is most probable the *Mongister* is a root of the same plant.

The blue-flowered *Gallium* and the madder of the Alps, known by the name of *Rubia lævis taurinensium*, gave the most beautiful red to M. l'Abbé Mazeas in his experiments on the dyeing of cotton. The common madder certainly yields a greater abundance of colour; but in many manufactories they prefer quality to quantity. The difference, however, would be of little consequence to the cultivator of any one of those plants. It were therefore to be wished that we did not, as at present, confine ourselves to the culture of the Dutch and Levant madder only. The latter yields a different shade from that used in the Indies, which is rather more crimson. By cultivating various species of rubiacea we might hope to procure a diversity of shades; besides, the soil, though inimical to one, may agree with another.

The root of the best madder has a lively colour, and when powdered and put on blue paper instantly adheres. Madder when powdered should be pasty and unctuous, like that which is imported from Smyrna, Tripoli, and Cyprus, etc., differing only in consequence of some difference in the soil. The Cyprus madder has the most aromatic smell, and feels resinous. Its colour is more fixed, darker, but less pleasing than that of the others. Madder when ground generally loses its unctuosity in drying, and therefore the best is only good for a year, after which it begins to decline.

The madder root seems to contain two parts mixed together, though of a different nature; the one subtle and penetrating, supposed by Hoffman to be of a saline, sulphurous nature, and the other earthy and astringent. These two parts are not intimately combined, in consequence of which, like the constituent parts of rhubarb, they act separately. It seems not therefore accurate to say that the colouring principle of the madder is merely of a soapy extractive nature. The saline, sulphurous part is indeed by nature soluble in water,

and there retains the red particles in a state of emulsion; these two parts are, however, very distinct, and are united only as aggregates. This their effect in dyeing sufficiently evinces: a fawn colour may be dyed by the epidermis and the heart of the root, which contain the greatest quantity of saline matter; on the other hand, the parenchyma alone gives a beautiful red colour; but it is necessary, in order to render it still more pure, to destroy the fawn tinge by which the red is sullied, and from which even the parenchyma is not exempt. Some experiments which I made on this root confirm this opinion.

I took some of the roots of the madder gathered in the environs of Paris; I dried it in the shade, and reduced it to powder. A quarter of a pound of this powder I put into a glass bowl, adding half an ounce of salt of tartar dissolved in twelve ounces of river water. I left the whole infusing for three days, frequently stirring with a stick to facilitate the extraction of the colour. I then filtered the red liquor; I poured it into another bowl, adding water soured with leaven in a small quantity. I covered the liquor, but in such a manner as to have a little communication with the external air. The fermentation took place by degrees, and at the end of six days the liquor, which was fawn colour, became tolerably clear; a dark red sediment remained at the bottom, but very beautiful, having the consistence of a thick balsam. Attempting to wash it, I perceived that it was much inclined to redissolve in water, doubtless occasioned by a salt with which it remained united. I was then determined to pour off by inclination as much of the water as I could. The residuum which I dried, became of a red brown and of a very hard consistence, so that when I wanted to use it, it was insoluble even in boiling water. I therefore concluded that the red particles of the madder root were of a resinous or bituminous nature.

To determine which I took some fresh roots reduced to

powder, pouring on it some spirit of wine as high as my two fingers, carefully stirring the substance several times during the day. The next day I decanted the red liquor, pouring on it some fresh spirit of wine, and stirring as at first. I continued to decant and to re-add fresh spirit till it was no longer coloured. I then mixed all the coloured liquors together, in order to distil them *per Balneum Mariæ* in a tin cucurbit. I drew off about three parts of the spirit, which was necessarily more rectified, but of a reddish colour. This spirit and the residuum I put into two separate bottles; the residuum or extract was of a darker and more positive red than a common decoction of madder. Some of the solution of salt of tartar poured on this extract produced a violet precipitate; oil of vitriol diluted, a yellow, and a mixture of the two produced a good red. In short, by pouring different solutions of alum, you obtain different shades of red, according as you did chalk, nitre, sugar of lead, or salt of tin; and all these precipitates when dry are insoluble in spirit of wine.

The first of these experiments proves incontestably that the two colouring parts of the madder root are distinct, and that the red colour of the one is fixed, independent of the other. By the second we perceive that these two parts, though in different states, have originally the same principles, and that the fawn colour part wanted only a certain coction (probably produced by the development of its acid, and the concentration of its other principles, or superabundant phlogiston) in order to be transmuted into the red part. It is certain that though the spirit of wine I made use of was perfectly dephlegmated, yet there was no possibility of giving fire to that which I had drawn off by distillation; I am therefore of opinion that all the phlogiston it contained combined with the juice of the madder root. It is also certain that the red of the residuum after distillation was as pure as the red of cochineal, and with-

out any mixture of the fawn. Hence it appears that the phlogiston of the spirit of wine, in this instance, produces an effect similar to that of animal fluids on the madder dye, and that the last serves only to augment its brightness and not its permanency.

I shall resume this subject when I come to speak of the dyeing of cotton.

The red part of the madder root may therefore be considered as a fixed oil, intimately combined with an acid, which gives it the consistence of a balsam nearly approaching to the nature of bitumen. This substance, we find, acquires still more consistence when united to the earth of alum. The little power of the acid and alkaline salts on this drug, when entered into the pores of a well-prepared cotton, is a conclusive demonstration with my experiments that this substance is of the nature of bitumen, or at least that, by its combination with alum, it acquires that nature.

Of Vegetables Furnishing a Yellow Dye

After analysing several vegetables furnishing yellow of the good dye, the quantity of oil extracted was too small to suppose that it could by its union with the earth of alum, as in the substances I have just mentioned, form an unalterable mastic. But even in this particular instance nature in withholding seems to favour us, for there is no colour from which the dyers so easily procure a permanent dye. Plants yielding this colour are very common, and the little alteration produced by the salts renders it as easy to fix as to find. Yellow being the nearest to white, is produced by the refraction of but a very small number of the rays of light. Plants containing this colour are at the same time provided with a considerable abundance of mucilage, which, combining with the alum, retains the

particles within the pores of the subject. The oil, which preserves other colours from the action of the aërial acid, is of no use with regard to yellow, since any other colour is changed into this by the effect of acids, and that yellow flowers are very little if at all changed by alkaline or urinous salts. To these causes therefore may be attributed the fixity of the yellow of the good dye; and that this colour is only so in reality when the plants produce it pure, and without any mixture of red or blue. The yellow particles of other plants, including either to green or orange, are of the false tinct.

Nevertheless those yellows which I call of the good dye, are not so if tried by the common process, no more than the red of cochineal, of kermes, etc., on wool, silk, and cotton stuffs, which ought not to be lixiviated; it is sufficient if they resist the action of the air and sun. There are particular methods of fixing colours still more solidly on silk and cotton, of which I shall speak hereafter, and for this reason, I say, that we should distinguish different degrees of the good dye. But that is not now the question: at present we have only to explain the theory of the good dye, such as it is for wool and silk.

Of the Colouring Drugs used in Dyeing without Astringents

Pastel, woad, or *guede* (in Latin *glastum*) is a plant from which is extracted a blue of the best dye. It appears to be a native of France, particularly of the provinces of Normandy and Bretagne, according to the testimony of Pliny and Julius Cæsar. The first says that in France they called it *glastum* (Pl. L. 22, *sect.* 2), a plant resembling a plantain, with which the women of Bretagne rubbed their bodies on festival days, and walked quite naked, like negroes. We read also in Cæsar's *Commentaries* that the Britons painted their faces blue with

the juice of this herb, called also *vitrum*, that they might appear more horrible in battle.

In France we have hitherto distinguished only two species of indigenous plants capable of dyeing blue of the permanent dye, namely, the cultivated and the wild isatis. Many botanists even assert that the first is only a variety of the second; but I think we may be authorised in considering them as two distinct species, especially as the leaves of the cultivated isatis are much larger than those of the wild, which is by no means the effect of culture, since both species are preserved in the king's garden, where they are still the same; as the seeds of the wild isatis are smaller than those of the cultivated, and that those of the one are yellow and of the other violet. We find in the *Dentelaire* a third plant analogous to the isatis, which is the *Plumbago* of Pliny, and the *Lepidium* of Gasper Bauhin; the English call it *Glastum sylvestre*. The leaves of this plant are indeed something like those of the isatis, only that they are slightly serrated; flowers purple; seed, the pericarpium of which is green, contains a juice which rubbed on paper instantly stains it of a purplish blue, which as it dries becomes much darker. These seeds dried and infused in water give a beautiful blue colour. The leaves of this plant, like those of the isatis, have an acrid and hot taste, and, like those, redden blue paper but very little, a proof that they contain but a small quantity of acid and a great deal of volatile alkali. I have no doubt that by treating them like pastel a blue colour may be extracted.

The fourth plant is the scabius, with blue flowers (*Scabiosa, folio integro, glabro, flore cæruleo*), very common in meadows: root truncated near the base, and for this reason sometimes called *Morsus Diaboli*, or Devil's bite, because the ancients supposed that the devils envied the human race on account of the virtues of this plant. Its leaves are of a dark green

colour; flowers a beautiful blue, also dark. The Swedes prefer gathering the leaves in the month of May, because they then contain juice in great abundance: they are used for dyeing of woollen stuffs, to which they communicate a beautiful green colour, and are prepared for this purpose in the same manner as the isatis.

The method of preparing this last has been long since known, and described in several works both ancient and modern. It consists in disuniting the integral parts by fermentation, which develops and separates the blue feculence from the other parts of the plant.

This plant formerly constituted a principal revenue in Languedoc, Normandy, and several of the provinces of Germany. It not only gives the most beautiful blue colour to stuffs, but its dye serves also as a ground for many other colours, rendering them on account of its volatile salt much more adhesive. The existence of this salt in the pastel is sufficiently demonstrable by the drops which stick to the boards where the pastel is prepared, but yet more by its urinous smell.

The dye of the isatis and other analogous plants is of the number of those whose colour is not obvious, but requires to be developed by a saline agent. But what is the nature of this feculence, consisting in itself of so many parts, and so intimately combined together that it is not in the power of fermentation to destroy their union? We know nothing positive of this matter; but the knowledge we obtain concerning the principles of plants by analysis, authorises conjectures, the probability of which is almost equivalent to demonstration.

M. Geoffroy (see *Memoirs of the Academy of Paris*, 1707) attributes the green colour of the leaves of plants to a rarefied oil, mixed with the volatile and fixed salts of soap, which remain attached to the earthy particles, while the greater part of the aqueous matter flies off. This conjecture seems so much

the better founded, as it accords with his experiments on the oil of thyme. Now if we suppose that the soap is a composition of water, salts, oil, and phlogiston, we can easily account for the leaves of plants changing colour.

It has been observed that the aqueous and saline principles predominate in vegetables during the spring, but in the summer and autumn, the oil. In the first season the green of the leaf is rather blue, which in summer flies off, and during the autumn it becomes at last yellow. The reason of this is doubtless that in spring, from the result of the combination of the salts with the phlogiston, a blue colour is composed, which appears darker or lighter in proportion to the quantity of the alkali interspersed in the aqueous juice of the plant, in which swims the resinous or earthy composition of the blue colour.

During the summer the heat of the sun carrying off the more volatile parts of the salts and phlogiston, there consequently remains only a part of the latter, which, joined to the alkali, would form a compound of a yellow colour, as all phlogisticated alkalis must in this season, if the soap did not continually furnish a fresh supply of salts and phlogiston, which partly repairs the loss resulting from the evaporation occasioned by the heat of the sun. In the autumn, on the contrary, when the sap no longer repairs this waste, the colour of the leaves must necessarily become yellow.

Plants furnishing blue feculæ, must therefore abound in salts, oil, and phlogiston. The colouring principle residing in the isatis is nothing more than a combination of phlogiston with the salts, oil, and earth ; and as M. Hellot observes, there are probably many plants of the same class that would furnish the same feculæ. This character depends no doubt on the quality of the oil contained in the plant, or the salts with which it is combined, but above all, on the quantity of phlogiston.

It is possible to extract from a great number of plants,

by fermentation, a black tenacious oil and a volatile salt, perfectly urinous and extremely penetrating, especially when rectified, in no respect differing either in taste or smell from volatile spirit of hartshorn or of blood or of sal-ammoniac (see *Trans. Phil. Ann.* 1674). In order to extract these principles, a large quantity of the leaves should be collected in warm weather; they should be gathered from the highest stalks, and heaped pretty close together. This heap quickly heats, especially in the middle, and the whole, except the exterior leaves, is resolved into a kind of paste, which when formed into little balls, is distilled in a glass retort. By this simple process a great quantity of liquor is obtained, and much black thick oil of the consistence of a balsam. The liquor being separated from the oil, and distilled in a large glass vessel, yields by distillation a volatile spirit which, to be very penetrating, requires only to be rectified.

Plants producing much fixed alkali, yield by this process a large quantity of volatile alkali, always in more abundance than the fixed alkali would be if extracted from the same plant by incineration; unctuous, and humid plants, such as the cochlearia, celandine, etc., ferment much quicker and with more heat than dry and aromatic plants.

May we not presume therefore that the ancients knew these qualities, and that they preferred the isatis only because this plant possessed them in a more eminent degree. The cochlearia is certainly of the same family. They have just discovered in Germany, or rather recovered, the art of extracting a beautiful blue colour from the chelidonium or greater celandine, in the same manner as from the isatis, observing only to let it ferment for a longer time.

In the pastel balls the feculæ are separated from the juice of the plant by an incipient fermentation, which was not continued long enough to separate from the feculence the oil and

volatile alkali, so that these principles being confounded with the cadaverous part of the plant, the colour is not visible, because obscured by the earthy and gross particles. Lime is used for their development because this saline substance, as well as fixed alkali, has the property of decomposing all neutral salts with a basis of volatile alkali. If a common fixed alkali be used, such as kelp or potash, etc., it would destroy while it developed the colour, because the volatile alkali evaporating, would carry with it the phlogiston. But the earth of the lime seizes the colouring principle as it quits the volatile alkali, retains it, and thus prevents the destruction of the colour. This hypothesis is so well founded that without the greatest attention to the second fermentation, when setting of the pastel vat, the colouring principles are entirely lost, from their promptitude to evaporate before they have had time to be retained by the lime or fixed by the earth; and during the whole time the vat must be supplied with lime, gradually, as the colouring principles develop. Heat is necessary for working the pastel vat, because without it the earth of the coloured lime would remain at the bottom of the vat in the form of a precipitate. Now in order that the colouring particles may adhere to the stuffs when plunged into the dyeing liquor, it is, as I have already said, very essential that these particles be suspended in the liquor, forming with it a kind of emulsion, which being equal throughout, and alike presented to the whole of the surface, may easily and equally enter within the pores of the stuff.

The principles extracted from the isatis by analysis naturally furnish an explication of the manner in which stuffs are dyed in the pastel vat, and also of the fixity of the dye. It may be conceived that the particles of the coloured lime, being extremely fine, are easily insinuated within the pores of the wool, especially by the help of a volatile alkali, whose action is so

very penetrating, and its particles forming with the oil of the plant a mastic, preserves the colour from the influence of the air. This dye takes effect on wool in the same manner nearly as the scarlet dye, only that, for the reasons above mentioned, the oil and the lime combined in the pastel vat produce a permanency that cannot be obtained from the scarlet dye. Moreover, the pastel can only be used for wool or woollen stuffs, the particles of the mastic being too gross to enter the pores of either silk, linen, or cotton.

Of Indigo

The colour of the feculæ of those plants which furnish the paste called indigo, may be called visible; for besides that this paste is of a dark blue colour, even the leaves of the plant are a bluish green.

Different authors, speaking of indigo, have given very different descriptions of this plant, as well with regard to its height and habit, as to the shape and number of its leaves, the form and colour of the flowers, and of the seed. Hence we may conclude that various plants of different species, genera, and even class, may produce feculæ capable of being made into indigo.

In America four species are distinguished, very different from those used at China, Japan, Java, in Persia, and Madagascar, etc.; their preparation is also different, probably owing to the various natures of the plants used in different countries. In the East Indies the leaves of the plant are fermented during the space of four days, when the grosser particles subside and the colouring feculæ remain suspended in the water, which are separated either by agitation or by the intermedium of lime. In America, on the contrary, the fermentation is generally completed in forty hours, which plainly proves that the plants

there used contain a much larger quantity of volatile alkali, by which the operation is rendered more difficult, owing to the danger of not stopping in time to prevent putrefaction, which is frequently the cause of failure in this operation.

The Portuguese, when they conquered the Brazils, discovereda plant similar to that from which the indigo is extracted in the East Indies. The natives knew no other use for this plant than to blacken their hair and rub their faces with it in order to affright their enemies, in the same manner as our ancient Britons; and the Germans formerly used the isatis [1] for the same purpose. The Portuguese began to prepare this plant as they had seen it prepared in the East Indies, and the same process is at present adopted by all the European colonies in America. If we except the time, the violence of the fermentation, and the apparatus of the vessels, their operation and produce were the same, the American becoming sufficient for the consumption of Europe, the importation of indigo from the East Indies was discontinued, a very small quantity excepted.

Though the indigo was fabricated in America for two hundred years, we were a considerable part of the time ignorant of the plant by which it was produced; but where is the wonder, since it was much longer before we knew anything of the nature of cochineal, and that we are still equally ignorant of a number of commercial drugs. The reason is, I suppose, because those who migrate in order to establish American colonies, have very little curiosity, and besides think more of their own interest than of giving us information. We may however presume that the greatest number are attentive to their own interest, and that the Europeans, finding the indigo

[1] "Femina canitiem Germanis inficit herbis
Et melior vero queritur arie color."—OVID.

plant in America, would cultivate it rather than introduce the culture of a foreign plant. In Malta they cultivated the same plant a hundred years ago, the culture of which is now neglected. There is actually but one dyer in the island, who sows it and keeps it for his own use. He follows the steps of his ancestors in his process; but we can easily conceive that the American indigo is greatly superior to what he makes.

The plant which the Arabs and Spaniards call anil, is called at Malta ennir. It resembles the chickweed in its leaves, only that the branches are shorter and broader, and woody like those of broom. It seldom grows higher than two feet, and even at the end of three years the branches are scarce an inch thick. Its flower is something like the heartsease, and its seed like those of the fenugrec. It is sown in June and gathered in November, and generally lasts about three years. The feculæ extracted from this plant in the first year are of a bad quality, reddish and heavy, not swimming in water like good indigo. The second year, the feculæ are in perfection, of a violet colour, light, and swims in water; but in the third year they degenerate, are heavy, blackish, and even inferior to that of the first year.

Of Substances used in Dyeing Fawn and Root Colour

This colour, in my opinion, does not deserve to be ranked amongst the number of those called primitive colours. M. Dufay is of the same opinion, who thinks, with reason, that this colour, philosophically considered, is a mixture of yellow and black. Nevertheless, as there are in nature substances furnishing this colour without being under the necessity of procuring it from any new combinations, and that these substances having in themselves a certain degree of fixity, without

requiring stuffs to be previously alumed, it may not be amiss to give reasons, or at least probable conjectures, relative to their nature.

The substances used for giving this colour are the green shell of the walnut, the root of the walnut, santal, sumach, etc. Many others might be added to those, such as the leaves of black horehound, the wood of the lote or nettle-tree, the *Uva ursi*, the *Iris palustris lutea*, and a considerable number of vegetables, which because of the facility of procuring this colour, are not used. These substances have in general a bitter and astringent taste, owing to the resin they contain, and which is formed by the combination of an acid with a thick fixed oil and phlogiston. The existence of this combination was long ago discovered in these substances, and since confirmed by their property of precipitating metals, especially iron, and of applying a superabundant phlogiston to that necessary for their reduction. The resinous particles of all these substances easily dye stuff, because being suspended in a state of emulsion, they have naturally less affinity with the liquor than with the matter to be dyed.

These substances, strictly considered, furnish no colour perfectly fixed. They owe their colour only to a phlogiston, superabundant to that which enters into the composition of the oil and resin; but this phlogiston not being volatile, there remains only the coloured particles of that portion of the phlogiston which enters into the composition of the resin. This is one of the causes why the black dye loses a part of its ground without being entirely defaced.

Of all the substances yielding fawn colour, galls are the most tenacious, for which quality they are indebted to the perfect combination of their principles, and therefore preferable in the black dye. They are also very useful in giving a

ground to silk intended for the crimson dye, and in preparing cotton for the madder dye, for the reasons I have already given in a chapter concerning the preparation of stuffs to be dyed.

Of Carthamus, Roucou, etc.

The flowers of the carthamus, or bastard saffron, furnish two separate colours, the same as the root of madder, a yellow and a red. The yellow is a mucilaginous juice, the red a resinous feculence; but the yellow juice wants only a more intimate combination of its principles to become resinous, and to acquire the same colour of the red feculæ. The colour of the petals proves this, which though yellow at first, changes to red as the flowers ripen. Hence we may presume that in Asia, where this plant originally came from, the flowers would yield more colour. These feculæ or colouring resins are always of the false dye, because composed of an acid and an essential oil extremely volatile. The same may be said of all vegetable flowers, with the same appearance of colour, particularly St. John's wort, on which P. Cotta made some experiments, but which experiments were never yet, nor ever can be of any use. In short, the plants yielding colour by depuration of their juices, or by the fermentation of their resinous feculæ, are very numerous. The juice of the hemlock, which deposits a green colour, is an instance of this kind. All these kinds of feculæ, however, may be rendered of use in the art of dyeing.

The feculence of the roucou is nothing more than the pollen of an American plant called *Vrucu*, to which the *Euonimus* has great affinity. The bitter and aromatic taste of this feculence, as well as the effect produced on it by spirit of wine, sufficiently indicate that it is, as well as the carthamus, of a resinous nature. This species of feculence easily enters the pores of

the subject to be dyed, and by its own astringency remains fixed, even without having previously alumed, because the essential oil which is one of the principles of resins, being combined with the alum, must on account of the acid destroy the colour of the feculæ. These dyes are therefore affected by the air only because of the aërial acid.

Of Black

Colours hitherto mentioned are communicated to stuff by means of substances which are conveyed into its pores. This, however, is not the case with black, as we are yet ignorant of any feculence possessing the qualities of the blue, red, or yellow colouring matter. Neither the black of bones, ivory, Ethiops Martial, etc., nor any other substance of the three kingdoms, whether simple or compound, could hitherto be rendered of any use in the art of dyeing, because being of a dry nature it is incapable of being introduced within the pores of the stuff, being neither attracted by the subject to be dyed nor by any astringent. It must be remembered that I have said, when speaking of this process, that in dyeing it is necessary there should be a reciprocal attraction, either on the part of the substance itself or on that of the astringent which it had imbibed, and the colouring particles. Now with regard to the black feculæ, this attraction can never take place, as they can have no kind of affinity, not even with the fluid, in which from their natural dryness they can never be suspended, consequently are placed at such a distance in the stuff as to withstand the power with which these substances are capable of attracting each other. Besides, however divided they may be, they are yet incapable of being attracted by the earth of alum, or any other earthy or metallic basis, these earths and the feculæ having no affinity to each other, the latter being

too dry, and the former exerting their attractive power only on oily substances.

Instead therefore of black feculæ, we are reduced to the necessity of procuring this dye from a combination of blue, yellow, and red. The famous fraternity of the Gobelins formerly pursued this method, giving their stuffs a blue ground of the pastel, then aluming, and afterwards dyeing in woad or madder. This is indeed the best method of procuring a solid black, since each of these dyes, taken separately, are extremely permanent. This practice was nevertheless discontinued, because being really expensive, the merchants rejected it for a dye procured at a much cheaper rate from drugs of an inferior quality. This colour is regarded with too much indifference, considering that the stuffs are liable to be injured by the nature of these drugs, and that by such impolitic economy we bring our manufactures into discredit.

Besides, these drugs, in the same manner as in the Gobelin process, produce a black only by combination. Galls, sumach, the rind of the alder-tree, logwood, etc., contain the three primitive colours, which are developed by the salts of copperas or iron. Permanency, however, cannot be expected from such mixtures and combinations, which on account of the various qualities of the different ingredients are only capable of giving a tinct. The feculæ of each of these colours have their different degrees of fixity, hence we may conclude that the least permanent being soonest destroyed by the effect of the air, those that remain predominating too much, form a new combination, which gives a cast of brown, maroon, grey, or any other shade of black, according to the substances that best stand the action of the air. It were therefore to be wished that we could find a black vegetable substance capable of dyeing black, and it is astonishing that our naturalists do not more particularly apply themselves to a subject so greatly deserving of their

attention, as well with regard to the dyeing of stuffs as to the importance of procuring an ink more durable than any now in use.

There is a tree in the Brazils called *Junipapuyawa*, and by botanists, *Pomifera-indica tinctoria* or *Genipa Americana*, the leaves of which resemble those of the walnut-tree. Its berries and leaves dye a blue-black capable of resisting the effects of soap. The flesh and fat of pigs and birds who eat these berries is penetrated with a violet colour, dark and indelible.

The berries of the *Christophoriana* or *Actea spicata*, poison berries or St. Christopher's herb, give, according to Linnæus, when boiled with alum, a black dye. Those of the *Empetrum procumbens* or *Erica baccifera nigra* give stuffs, according to the same author and by the same means, a purplish black. Our barberry or prickly sorrel resembles in many respects the *Christophoriana*. The *Erica baccifera* being of the same genus of the myrtles, we might try if our myrtles—*vitis idœa* or *vaccinum*, used by the ancient Gauls in dyeing of purple—would not with astringents produce a permanent black.

The fruit of the *Anacarde* or *Acajou* nut gives a fixed black. The trunk of the *Vernix* tree, *Toxico tendron*, distils a juice producing the same effect. M. l'Abbé Sauvage first discovered that the juice of the *Toxico tendron Carolinianum foliis pinnatis, floribus minimis herbaceis*, dyed linen a much deeper black than any other known preparation, and with much less acrimony. M. l'Abbé Mareas describes two species of *Toxico tendron* cultivated at St. Germains-en-Laie in the gardens of the Duke D'Ayen; one is called *Triphillum folio sinuato pubescente*, and the other, *Triphillum glabrum*, both from Virginia. Their leaves contain a milky juice, which in dyeing becomes a deep red, and which if it falls upon linen communicates the same colour. They give a much finer black,

and in much less time than the juice of that species discovered by the Abbé Sauvage, and, besides, resist the effect of the lixiviums.

The turpentine tree, the *Lentisque* or mastic tree, the rhus of Tournefort, or sumach, have all of them leaves giving a milky juice. These several plants are of the pistachio family. The leaves of the *Monotropa* of Linnæus, the choakweed, or *Orobanchoides* of Tournefort, turn black, which seems to indicate that black feculæ may be extracted from it. Apothecaries prepare a very fine black extract from the viscous juice of the *Hypocriste.*

A similar extract may be obtained from the grain of the acacia, a tree which, like the indigo, bears leguminous flowers. Something of the same kind may be extracted from the liquorice root, a plant of the same genus, the leaves of which when fermented give black feculæ evidently existing in this plant. These observations are all worthy of attention.

OF THE DYEING OF COTTON THREAD

Of Cleansing

It is necessary, previous to the dyeing of cotton thread, to cleanse it from that unctuous matter by which the dye is prevented from penetrating its pores. For this purpose they make use of sour water, which is prepared by throwing some handfuls of bran into hot water and letting it stand four-and-twenty hours, or till the water becomes sour, when it is fit for use. These sour waters, however, cleanse the cotton but very imperfectly, carrying off only the superficial part of the unctuous matter, which river water would do as well. The lixiviums of ashes are more effectual, and therefore all

fixed alkalies, particularly kelp, or even the ashes of new wood, are, for the reason I have already given, generally preferred for this operation. The salts are extracted in the same manner as by the bleachers; and the cotton is then steeped in these lixiviums, which, like the silk, is enclosed in a clean linen pocket or sack, to prevent the skeins from tangling; it should boil for a couple of hours. When perfectly cleansed, the pockets sink to the bottom of the liquor, because the impeding matter being removed the water penetrates the pores. The pocket is then taken out of the copper, the skeins separated from each other, and washed at the river. They are afterwards wrung on the peg, and again rinsed till the water comes off clear. The skeins are then spread on the perches to dry.

Of the Colours Employed for Dyeing of Cotton Thread

The colour of cotton thread designed for the fabrication of stuffs should not only resist the air, but even soap. Dyers are confined in the choice of their colouring substances, consequently in the shades of their colours.

The colouring substances are indigo, madder, and woad; for hitherto we know of no other substance capable of forming a bitumen sufficient to withstand the power of fixed alkalies. The three principal colours are therefore blue, red, and yellow, to which may be added black, and the shades resulting from a mixture of these primitive colours taken by twos or by threes.

Of Blue

There is no difficulty in dyeing cotton thread of this colour; the only requisite is a cold vat, and made in the following manner:—

The blue vats are generally raised in great brandy pipes

newly emptied, or in hogsheads that had been used for oils, containing about five hundred quarts. If the latter, it should be well cleaned by slaking lime in it, and by scrubbing the inside of the vessel with a broom till the grease is absorbed by the lime.

The quantity of indigo generally used for these vats is from six to seven or eight pounds. This indigo should boil in a lixivium made with double its weight of potash, and of lime equal to the weight of the indigo, which should be drawn off clear. But before these substances are boiled together, the indigo, in different parts and at different times, is pounded in a mortar, moistening with water sufficient to prevent it from flying off in dust, but not so great as to hinder it from being pounded.

Each parcel of the indigo as it is pounded and reduced into paste, is put into an iron boiler containing about twenty quarts. When it is all pounded, the boiler filled with lixivium, and the fire put under, it is then suffered to boil till the whole of the indigo being diffused in the liquor rises to the surface in a kind of cream, and when striking the bottom of the boiler with a stick, it appears by the sound to contain no substance. By these indications you will perceive when the indigo is boiled; but if the liquor in the boiling should evaporate too much, it will be necessary to add more of the lixivium to prevent it from sticking.

While the indigo is boiling you slake the same quantity of quicklime, adding about twenty quarts of warm water, and double the quantity of copperas dissolved in it. The copperas when perfectly dissolved, is poured into the vat, previously about half filled with water. The indigo solution is then poured on to it, minding at different times to rinse the copper with the remaining lixivium, and then adding the whole, that nothing should be lost. When poured in and

the vat filled with warm water to about two or three fingers of the edge, it is stirred with a stick two or three times a day, till it becomes proper for dyeing, which it will be in about eight-and-forty hours, and often sooner, according to the temperature of the air, by which the fermentation is more or less accelerated.

To this pastel vat several dyers add common madder and genestrole, which they boil with the indigo; but these substances are of no use. The quantity of the pastel must be too small to be of any service, and the madder when cold can produce only a fawn colour, which must darken the blue at the expense of its brightness.

The genestrole by giving a green colour deceives the dyer, who supposes the vat in a proper state for dyeing when it is not; the green colour of this liquor being in fact produced only by an equal distribution of the indigo throughout the several particles of this fluid; hence by thus artificially greening, you give only the appearance of an effect, which can only be occasioned by a division of the indigo feculæ.

When boiling the indigo it is the custom to add some handfuls of bran, as useful both in correcting the bad qualities of the water and in cleansing the vat.

The cotton to be dyed in these vats is distributed into hanks and suspended across over the vat. These hanks, first steeped in warm water, lightly wrung, and then put on the rods, are frequently returned till they have taken the colour equally: you proceed thus till they have imbibed the shade required, if the vat be strong enough; but if not, they should be dipped immediately in another vat. When perfectly dyed, and before washing at the river, it is the custom with many to wring them over the vat, and in order to ungreen, to shake and open them; but it were much better to drain them over the dyeing liquor and to ungreen in the rinsing water. In washing the cotton when taken out of the dye, there is no danger

of losing any part of the indigo, provided it be not washed in a running water, and therefore they provide for this purpose troughs or barrels full of water, in which they plunge the dyed cotton, stirring carefully till it is entirely ungreened. This water is afterwards useful either in filling the vats that require it, or in raising new ones.

In this vat are dyed the blue and white skeins, and by the following simple manœuvre:—They divide the skeins into equal parts of any size, alternately binding them round with a light thread, by which means the skeins, when plunged into the vat, are coloured only in those parts that were left exposed to the dye. When thus dyed and dried, and the binding thread cut, the skein remains *catiné* or mottled.

If the vat does not come to, though you have no reason to suppose the indigo exhausted, which can be known only from experience, and being enabled to calculate nearly the produce of a pound of indigo according to the shades required, it may be recovered by feeding; that is, by adding to it either copperas or lime, as it may require, or as from experience you are enabled to judge by its appearance. If black, it requires copperas; if yellow, lime. These are in general all the directions that can be given with regard to the government of these kind of vats, which yield more or less in proportion to the goodness of the indigo, and frequently to the dyer's method of conducting the vat; but experience is better than precept.

These are the only vats hitherto known for dyeing cotton velvets or calicoes, the pastel vat not being strong enough for the purpose, no more than is the logwood vat with lime used for silk, the urinous vat, nor any other indigo vat.

Calicoes died in this vat should be put into a small net bound to an iron or wooden hoop, with a stone or weight affixed, in order to keep it suspended at what height you choose, and to prevent it from rising to the surface. Three or four cords

tied to the circumference are fastened to the edge of the vat in such a manner as to sink the net about two-thirds deep. By this means the calico may be plunged without any risk from the grounds, which in stirring would otherwise spoil the dye. It is therefore plunged into the liquor with caution, frequently handling and cooling by the rod, carefully sinking that it may be evenly coloured, and thus continuing till it has taken the shade required, either in one or more vats, according to their strength and to the depth of the colour. It is then taken out, folding it at the same time with the rods, and then put to drain on a pole placed over every vat for that purpose. It should not, however, remain too long in this situation, because, not ungreening equally, it would be watered and spotted ; it is therefore taken down and aired on the pavement of the dye-house ; but the ungreening, as I have already said, is completed either in the troughs or in running water.

As cotton velvet is extremely subject to roll on the rods whilst wet, and the pile easily laid, which when dyed in these hogshead-vats renders the colour uneven, it was therefore found necessary for cotton velvet to prepare the same dye in square vessels, such as I shall hereafter describe when I come to speak of the blue ground given to calicoes intended for white, commonly called China white.

Of Red

To dye cotton red requires three preparations, viz. cleansing, galling, and aluming. The operation of cleansing as above.

With regard to the galling, any kind of galls may be used in case of necessity ; or even tan may be substituted ; but that requiring more, it would not answer the purpose so well. The black Aleppo galls, because less suffices, are preferable to the white galls, which, though cheaper, make the expense

come nearly equal. The Aleppo galls are, however, liable to dull the colour, which though easily revived, the white not producing this inconvenience, are generally preferred by most dyers. It requires nearly five quarts of liquor to drench one pound of cotton; so that for twenty pounds, five pounds of pounded galls are boiled in about one hundred and twenty quarts of water; it should boil for two hours, or till by pressing it between the fingers it breaks easily.

This liquor is drawn off clear, and poured into a tub into which, when cold, or even whilst warm, the cotton, which was before divided into hanks of about eight ounces each, and tied with a thread to prevent them from tangling, is dipped. Suppose, for example, that having about forty of these hanks, and a hundred quarts of the gall liquor, a part of it necessarily evaporating in the boiling, five quarts of this liquor is taken out of the tub and put into a trough, into which you dip two skeins at once, carefully working them till they are soaked. They are then taken out and laid in an empty tub, pouring over them the remainder of the liquor in which they had been soaked; five quarts more are then taken out of the tub containing the gall water, poured into the trough, and two more hanks dipped into it, and so on successively till the whole is galled. The gall liquor should be stirred in the tub every time you take out, that the whole of the cotton may be galled equally, which it would not be were the grounds to settle at the bottom. This operation finished, if any of the liquor remains, it is poured on the galled cotton, being orderly ranged in the tub, where, after remaining twenty-four hours, it is taken out skein by skein, gently wrung, and then put to dry.

The aluming for the cotton consists of about four ounces of Roman alum for every pound of the substance. Having pounded the proper quantity of alum, it is dissolved over the fire in a copper containing a sufficient quantity of water,

taking care not to let it boil, otherwise it would lose its strength. The liquor is immediately poured into a tub or trough of cold water, proportioned to the quantity of the cotton, so as that the whole of the liquor may be as that of the galling, a hundred quarts for every twenty pounds of cotton. It is the custom to add to this alum liquor a solution partly composed of arsenic and white tartar, with one part of the lixivium of kelp. The first solution consists of one grain of arsenic and two grains of white tartar in two or three quarts of water. When the water in the copper boils, the arsenic and tartar, well pounded, is put into it, and kept boiling till the liquor is reduced to about half. When cold it is strained and put into bottles or vessels, which should be stopped and kept for use.

The kelp lixivium is made with about half a pound to a quart of water. You will know if this lixivium be sufficiently strong, when by putting an egg into it the point only appears on the surface.

You then add to the alum liquor for this supposed twenty pounds of cotton, twenty quarts of the solution and three quarts of the said lixivium, observing nevertheless that the whole of the water used in mixing the alum and other substances be always in the proportion of five quarts of liquor to every pound of cotton. The twenty pounds of cotton are then plunged into this astringent pound by pound, in the same manner and with the same precaution as in galling; it is afterwards wrung, but without being too much squeezed, and then slowly dried.

Some dyers never use the solution of tartar and arsenic with the alum, rationally supposing that these substances, as they rust and yellow the red colours, would be prejudicial to the dye: the red furnished by madder being already too much inclined to this shade, requires rather to be saddened, and for this reason partly the kelp lixivium is added to the

aluming. Several therefore use six quarts of this lixivium instead of three, and these six quarts containing the salts of about three pounds of kelp, which by supposing the kelp ashes to contain a quarter of its weight of salt, is in proportion of half an ounce to every quarter of a pound of alum.

Instead of the solution of tartar and arsenic, others make use of a solution of sugar of lead, prepared separate. It should be observed in this particular, that when the sugar of lead is dissolved in common water, it becomes turbid and whitish, because plain water not dissolving this salt perfectly, a kind of partial separation of the calx of lead takes place; but by mixing a sufficient quantity of distilled vinegar with the water, the calx entirely disappears and the solution is complete.

When the cotton is taken out of the astringent it is lightly wrung on the peg and dried. The more slowly it dries, and the longer before it is maddered, the brighter the colour. Twenty pounds of cotton are generally dyed at the same time; but it were still more advantageous to dye only ten, because when there are too many hanks to work in the copper, it is very difficult to dye them equally: the hanks first immersed having time to take a great deal of colour before the last are put in; for as the first cannot be returned upside down till after the last are plunged, it is morally impossible that the dye should be even.

The copper in which this ten pounds of cotton are dyed should contain about two hundred and forty quarts of water, that is, twenty quarts of water for every pound of cotton; its shape should be an oblong square and about two feet deep. It should also be wider at top than at bottom; the difference however should not be too great, because in that case the hanks laid slanting on the sides would be liable to spot. As several dyers have erred for want of knowing how much water the copper should contain respecting its dimensions, and that

the greater part of the brasiers are likewise ignorant in this particular, it may not be amiss in this place to add a short and easy method of finding the contents of a vessel.

In the first place, suppose the vessel round or cylindrical, you begin by measuring the diameter; you then seek the circumference, afterwards the surface; and at last by multiplying the surface by the perpendicular height, the product is the cube sought for, and determines the contents of the vessel.

For example, a copper twenty-two inches deep by thirty diameter; to find the surface, take the proportion of the diameter to the circumference, which is as seven to twenty-two: state as in the Rule of Three, the first number 7, the second 22, and the third 30; the fourth number will be the circumference. This fourth number is found by multiplying the two middle numbers, 22 and 30, by each other, and dividing the product 660 by 7, the first number; the quotient 94 is the circumference sought for. If a square or oblong vessel, as in the present case, you have the circumference by adding the length of the four sides.

Multiply afterwards the half of the circumference by the radius, that is 47 by 14, the product 705 is the number of square inches, and consequently the surface of your vessel.

At last multiply 705 by 22, which is the perpendicular height, the product 15510 is the number of cubic inches your vessel contains. If it is larger at top than at bottom, it is necessary, in order to determine the circumference, to take a middle number between the breadth of the top and the breadth of the bottom, as if the copper be thirty-three inches at the top and at bottom twenty-seven, the middle number and real diameter is thirty.

Having multiplied the surface by the perpendicular height, you must reduce the inches to feet. Now the square foot

being equal to 144 square inches, and the cubic foot to 1728 cubic inches, you must therefore in this example divide 15510 by 1728, the quotient $9\frac{1}{11}$ will be about the number of cubic feet in the copper, and as a cubic foot contains 35 quarts, consequently the copper contains 318 quarts Paris measure (the Paris pint is our quart). To madder ten pounds of cotton, a copper containing 240 quarts of water is made hot. When it is rather too hot for the hand, six pounds and a quarter of good Dutch grape madder is put into it, and carefully opened and diffused in the liquor. When it is well mixed the cotton, which had been previously passed on the rods, and suspended on the edge of the copper, is dipped into it hank by hank. When it is all dipped, the hanks on each rod are worked and successively turned upside down, beginning from the first that was put in and so proceeding to the last, returning to the first, and thus continuing without intermission for three-quarters of an hour, always maintaining an equal degree of heat, but without boiling; the cotton is then raised and drawn out upon the edge of the copper, and about a pint of the kelp lixivium poured into the liquor. The rods are then passed through the threads by which each hank is bound, and the cotton put back into the copper and boiled for about twelve or fifteen minutes, keeping it entirely immersed during that time. It is at last raised, gently drained, wrung, washed at the river, and wrung a second time on the peg.

Two days afterwards the cotton is a second time maddered, about eight ounces of madder to every pound; that is, five pounds of madder added to the dyeing liquor. The liquor is then worked in it in the same manner as in the first maddering, with this difference, that none of the lixivium is added, and that the liquor is made of well water. This maddering being finished, and the cotton cooled, it is washed, wrung, and dried.

To brighten this red you put into a copper or trough a

quantity of warm water sufficient to drench the cotton, pouring into it about a pint of the lixivium. In this liquor you immerse the cotton pound by pound, leaving it in for an instant only, when it is taken out, wrung, and dried.

This operation, as it is practised at Rouen, I have exactly described, but it should be observed that this method of dyeing in two liquors has no advantage. For besides that it consumes more time and wood, the second maddering cannot furnish much dye, considering that the astringent salts are exhausted by the boiling of the first maddering, consequently that the cotton when deprived of these salts cannot take the dye. I propose therefore another method now pursued with success by several dyers: it consists in giving the cotton two alumings, and afterwards dyeing in one liquor only. By this means it takes the dye much better, and acquires more depth, because the whole of the madder turns to advantage. With respect to brightening, it is a needless operation for red cotton destined for the fabrication of calico, because the colour is brightened after it is woven, by dipping in warm water sharpened with a little of the lixivium. When the cotton is taken out of this water, if washed at the river and spread on the grass, the red brightens much better than by any other operation.

Adrianople Red

The reds of which I have been speaking are vulgarly called madder reds, though the reds I am going to describe are equally obtained from a species of madder coming from the Levant. The latter, however, commonly called *lizary*, furnishes a dye incomparably finer than that produced by the best Zealand madder; it is, however, the fashion to call the red of madder the first dye, and the Adrianople red the second. The process of the latter I shall give in this place.

When you have a hundred pounds of cotton to dye, you put a hundred and fifty pounds of Alicânt soda, enclosed in clean linen, into a tub. This tub should be full of holes at the bottom, that the liquor may run into another tub underneath. The hundred and fifty pounds of soda being in the upper tub, is covered with three hundred quarts of river water, measured by wooden pails containing each twenty-five quarts. The water that passes from the first tub into the second is again poured over the soda at different times, till it has extracted all the salt. This lixivium may be tried with oil : if it uniformly whitens and that it mixes well with the oil without any appearance of separation at the surface, it is then sufficiently saturated with the salt. It may be also tried with a fresh egg, as I have said above. You again pour three hundred quarts of water over the soda contained in the superior tub, in order to extract the whole of the salt. Two similar lixiviums are afterwards made, each with the same quantity of water, as had been used for the soda, viz. one hundred and fifty pounds of fresh wood ashes, and the other with seventy-five pounds of quicklime. These three lixiviums being clarified, a hundred pounds of cotton are put into a tub and watered with each of these lixiviums in equal proportion. When it has perfectly imbibed these salts it is put into a copper full of water without being wrung, and boiled for three hours; it is afterwards taken out and washed in running water. This operation being finished, the cotton is dried in the air.

A quantity of the above-mentioned lixiviums is then poured into a tub in equal portions, so as to make four hundred quarts. In a part of this liquor twenty-five pounds of sheeps' dung with some of the intestine liquor is well diluted by means of a wooden pestle, and the whole strained through a hair sieve. Twelve pounds and a half of good olive oil poured into this mixture, when finished, instantly forms a soapy liquor. In

this the cotton should be dipped hank by hank, stirring every time, and with the same precautions I have already recommended in the aluming of cottons destined for the madder red. The cotton having remained twelve hours in this soapy water, is then taken out, lightly wrung, and dried; this operation is repeated three times. The liquor that runs from the cotton when wrung, falling again into the trough where the cotton is laid, is called *sickiou*, and should be kept for brightening.

When the cotton has been dipped three times in this soapy water, and afterwards dried, it is again dipped three times in another composition made in the same manner as the first, with four hundred quarts of lixivium and twelve pounds and a half of oil, but without the sheeps' dung; the remainder of this liquor is also preserved for brightening. The cotton having been dipped in this liquor three times, with the same precautions, and left in it the above-mentioned time, it is then carefully washed at the river to divest it entirely of the oil, without which the aluming would not take effect; having been washed, it should be as white as if it had been bleached.

When dry, you proceed in the aluming, which is done twice successively, but it is needless to give a detail of what has been sufficiently explained in the article upon madder red. It is enough in this place to say that the galls, about a quarter of a pound to every pound of cotton, should be pulverised; that six ounces of alum should be put to the first aluming; for the second, four ounces; and at last, that an equal quantity of the lixivium be added to the alum water. We must also observe that it were best to make an interval of three or four days between each aluming, and that no other astringent be added, all metallic salts being in general injurious to the beauty of the colour.

Some days after the last aluming you proceed to dyeing in the same manner as above, only using two pounds of lizary in

powder for every pound of cotton, and before you dye, adding to the liquor about twenty pounds of liquid sheeps' blood: it should be well struck into the liquor, which should be carefully skimmed.

In order to brighten the colour the cotton is dipped in a lixivium of fresh wood ashes, dissolving in it five pounds of the best white Marseilles soap; the water should be warm before the soap is put into it. In this mixture the hundred pounds of dyed cotton is immersed, and worked till it becomes perfectly penetrated. Six hundred quarts of water are then put into another copper, and when warm, the cotton, without squeezing it out of the first, is put into the second, and boiled for three, four, five, or six hours over a very slow fire, but as equal as possible, carefully covering the liquor to keep in the vapour, that none may escape but what passes through a funnel of small reeds.

Some pieces of the cotton are taken out from time to time, and when sufficiently revived and washed thoroughly, the red is perfect. The cotton may be also brightened in the following manner:— When washed and dried immediately after dyeing it should be soaked in the *sickiou* for an hour, well squeezed, and also dried. When dry, you dissolve for every hundred pounds of cotton five pounds of soap in a quantity of water sufficient to cover the cotton. When the water is warm the cotton is immersed, and having well imbibed, is put into a copper with six hundred quarts of water; the whole is boiled very slowly during four or five hours, keeping the copper covered to prevent the steam from going off. The second method makes the red much brighter than the finest Adrianople carnation.

Observations on this Dye

The process I have just described was practised at Darnetal, and in other manufactories of France, according to instructions

communicated by a person who had seen this process in Turkey. But whether his observations were inaccurate, whether he concealed a part of the mystery, or whether the success of the operation depended on the concurring circumstances, accompanying the various mixtures, I know not. Few, however, by closely observing this process, have hitherto obtained a red either so permanent or so beautiful as the red of Adrianople, and those who have succeeded think it but just to reap the advantage of their secret. On this subject, however, several not unuseful reflections may be advanced.

First. The manner of purging the cotton indicates that this process is capable of damaging considerably, and of rendering the cotton very brittle owing to the sharpness of the lixivium in which it is steeped; so burning in its nature as to make holes in the legs of the workmen who tread it with their feet. It is therefore more simple and less dangerous to cleanse the cotton in six quarts of lixivium to every pound of substance, and containing only six ounces of kelp for every six quarts; to boil the skeins in it afterwards, enclosed in clean linen pockets, as I have already said on the article "Of Cleansing."

By this method the cotton would be sufficiently cleansed without being spoiled, the kelp may be even reduced to half the quantity, substituting in its place double its weight of fresh wood ashes, which would answer quite as well.

Secondly. That the failure of many dyers is owing to their not sufficiently divesting the cotton of the oil, which prevents both the galling and aluming from taking effect. The mixture of the lixivium and oil not being well made, or the lixivium being too weak, the oil forms with it but an imperfect combination. This oil therefore, separating and swimming on the surface of the lixivium, sticks to the cotton, which it greases, and, by obstructing the pores, prevents the gall from penetrating.

Great attention therefore should be given to the lixivium in order to extract all the salt of the kelp, and to use quick-lime, which is absolutely necessary to render this lixivium caustic, a quality without which the oil cannot possibly form a combination with the alkali, consequently can make no soap.

In Europe the oil of olives is substituted instead of the oil of *Sesamum*, which is used in the East Indies and in Turkey, but the nature of these oils makes no difference in the operation. The oil of *Sesamum* differs from the oil of olives only because it is thicker, consequently nearer to the nature of animal fat or wax; but the conclusion resulting from this difference is that less of it may be required than of the oil of olives. Were the oil of *Sesamum* absolutely necessary, it might have been easily procured. The *Sesamum* is a species of foxglove that grows in the Indies, but is cultivated in Italy, and especially in Sicily, where it is called *Giurgulena*. The same kind of oil may be obtained from plants analogous, such as the *Gratiole*, the henbane, etc., but the plant whose seed resembles it most is the convolvulus, or *Lizeron*.

It is certain that the process brought from Adrianople might be greatly abridged; but we must leave the secret to those to whom it belongs, and I am besides convinced that a memoir on this subject will be presented to the Academy of Sciences, and therefore will not anticipate.

With regard to the sheeps' dung and intestinal liquor, it is of no use in fixing the colour. But we know that these substances contain a large quantity of volatile alkali, quite developed, which has the property of rosing the red colours. If the bones of animals owe to their tenacious gluten the faculty of retaining so strongly the madder colour, the vivacity of this colour may be attributed, as from experience we learn, to their volatile alkali. It were absurd to imagine that the

Europeans only had discovered this phenomenon, as it may be rationally supposed that the Indians, having perceived it by accident, sought to imitate what chance had brought to their knowledge. It is certain that in the red dye of the *Maroquins*, the process of which was brought from the Levant, they prepared the goat skins for dyeing with dogs' excrement, having found it effective in exalting the dye of the lac.

In the dyeing of cotton thread it is common to mix the sheeps' dung with a lixivium of fixed alkali, by which the volatile principle of the dung is retained, and consequently putrefaction prevented. By dipping the cotton several times in this soapy liquor it is impregnated with the predominating alkaline principle, and we know by experience that substances once impregnated with volatile alkali, for example chemical vessels used in extracting it, for a long time retain a smell very like the smell of musk, even after having been well scrubbed with sand, ashes, soap, etc. Every time the cotton is dried when taken out of this liquor the evaporation of the aqueous particles (the alkaline principles being changed into earth) produces a stronger adhesion in the pores of the cotton. From the union of this earth with a portion of the oil employed, a mastic is the result, which is afterwards completed by the alum, and this in a word is the theory of the fixity of this colour.

Linen thread may be dyed in the same manner, only that previous to its being purged like the cotton thread, it is usual to boil it in water, adding for every pound of thread a quarter of a pound of chopped sorrel. Oil of vitriol is, however, more convenient and better than sorrel; but I refer my reader to what I have already said upon the article " Of Thread," observing only that by this process the linen thread always takes less dye than the cotton, owing to the difference of their pores

Of Yellow

For this colour the cotton should be first well purged in a lixivium of fresh wood ashes, and afterwards well washed and dried.

You then prepare another liquor, made by dissolving in the water, when ready to boil, about a quarter the weight of the substance to be dyed, of Roman alum. The skeins are plunged into this alum liquor, returning them on the rods for some minutes. When equally penetrated throughout, the threads by which the skeins are tied being passed on the rods, the hanks are laid on the trough containing the alum liquor. The copper or trough is then covered, it being sufficient to keep the liquor hot without boiling. The cotton, having been thus infused for twenty-four hours, is then dried, but without washing. We must observe that the longer it remains dry the better it takes the colour, and that the washing may be even dispensed with previous to the yellow dye.

A strong weld liquor is afterwards prepared, adding for every pound of the substance to be dyed a pound and a quarter of weld. The cotton or thread having been previously alumed, is then immersed, the boiling checked with cold water, and the substance worked till it has taken the shade required.

The whole when dyed is plunged into a very hot liquor, but not boiling, made of blue vitriol, a quarter of a pound for every pound of the substance. When it has remained for about an hour and half, the whole, without washing, is thrown into another liquor, composed of about a quarter of a pound of white soap for every pound of the substance. Having been well worked and the threads opened, it should boil for three hours, or more if you think proper. The soap might be diminished to half the quantity, but the full proportion does better.

This operation finished, the whole is well washed and dried.

If you desire a dark or jonquil yellow, neither the linen nor cotton should be alumed; but for every pound of thread should be added two pounds and a half of weld. When it has been dipped and well worked in this liquor till it has taken the colour equally, it is raised above the liquor, and half a pint of the kelp lixivium poured into it, made as I have directed in the article upon red. The thread is then returned upon the rods, dipped in this liquor, where having remained for a full quarter of an hour it is taken out, wrung, and dried.

The lemon yellow is done after the same manner, only that for every pound of thread you put but one pound of weld, diminishing the verdigris in proportion, or even omitting it entirely by substituting in its place the alum liquor. By this means the yellow shade may be varied *ad infinitum,* and without any difficulty; in brightening and fixing the colour, however, the above method must be always observed.

This method of fixing the colour of the weld, so accidentally discovered, is a striking example of the ancient operation which they termed *coloris allegatio.* It were to be wished, in order to extend the use of it to other colours, that it were possible to discover why calx of iron and copper has this property. It seems to proceed from the same cause which makes both these metals soluble in fixed alkali, differing in this particular from all other metals. M. Geoffroy supposed a bituminous matter to exist in iron, which is very probable, as also in copper. It is very certain that you give fixed alkali the property of dissolving other metals by phlogisticating with bullock's blood: does this proceed from phlogiston or from the animal oil, and a certain tenacious gluten which it is extremely difficult to separate from the Prussian blue, and different from phlogiston?

Cotton velvet is dyed with the root of a plant called *Curcum*

or *Terra-merita*, a species of rush which comes from the East Indies. It gives a beautiful colour ; but if dyed in the common manner has but little solidity. I know by experience that this colour may be fixed by dipping the linen or cotton thread in a solution of sulphur of antimony in the lixivium of fixed alkali : it will then perfectly resist the air, and cotton velvet thus dyed is very pleasing to the eye.

Of Green

Linen or cotton thread to be dyed green, after having been previously cleansed, should be dyed in the blue vat according to the shade required ; it should then be well rinsed in water and dried. It is impossible to give any positive rules concerning the ground of the blue or of the yellow, as that depends more or less on the colour you wish to predominate, or on the ground for the mixture required. Custom and the eye must be the dyer's guide in this particular.

Cotton velvets are seldom dyed with weld. To dye green they are yellowed with *Terra-merita*, and afterwards greened with a composition of the Saxon blue ; nor is it of any consequence whether you begin with the blue or the yellow.

Cotton velvets, as well as the skeins, may be dyed green in a single liquor and by a very simple process, but which will produce only green water or apple green.

Dissolve two ounces of verdigris in a very small quantity of vinegar, then add about half a pint of vinegar, pour the whole into a bottle, cork it well, and keep it in a stove for a fortnight. Four hours before it is used you boil two ounces of pearl ashes in a quart of water till reduced to half that quantity. Draw it off clear, adding it to the verdigris and vinegar mixture, keeping the whole hot. Prepare the thread by dipping it in an alum liquor, about an ounce of alum and five quarts of

water for every pound of the substance. Moisten it in this liquor as hot as you can bear it to your hand. The thread or velvet is then raised, the verdigris added to the liquor, and the substance again dipped and dyed.

Of Violet

The most common method of dyeing thread and cotton violet, is immediately to give them a blue ground in a vat proportioned to the shade required, and then drying. They are afterwards galled in a liquor containing, for every pound of the substance, three ounces of galls; they remain twelve or fifteen hours in this gall liquor, when they are taken out, wrung, and again dried. Meanwhile a logwood liquor is prepared by boiling for three or four hours, in fifteen or sixteen quarts of water, about half a pound of logwood for every pound of the substance. The half of this liquor is afterwards poured into a trough, and the cotton dipped in it till it has equally imbibed the colour, when it is taken out, and for every pound of cotton or thread two drachms of alum and one of verdigris dissolved is added to the liquor. The skeins are again dipped on the rods and returned during a full quarter of an hour; they are then taken out, cooled, and again entirely immersed for another quarter of an hour, when they are taken out and wrung. This dyeing liquor is at last emptied out of the trough, and the other half of the logwood liquor poured into it, with the addition of two drachms of alum; the thread is again dipped till it has taken the shade required.

This second logwood liquor, as well as the first, may be more or less strong in proportion to the shade required, in such a manner that, if very deep, you double the quantity of the logwood for the second liquor only; but as one boiling does not extract the logwood dye, you may after the first dye, by

way of economy, pour fresh water on the remainder of the logwood. It should be again boiled, and the weakest of it may be used for the first dipping.

This violet resists the air tolerably well, but nevertheless cannot be deemed of the good dye. Very permanent violets are produced by combining the madder dye with astringents. This has the advantage of being neither tedious nor expensive; it requires only that the thread should be impregnated previous to its being maddered with an astringent: as the basis of this astringent is the same commonly used for black and its various shades, it may be necessary in this place to give the composition.

Take a hundred quarts of sour wine, bad vinegar, or small beer; put to either of these liquors twenty or five-and-twenty pounds of old iron, having exposed it for two nights to the dew. Wet with some of this beer about twelve pounds of rye-meal, or coarse bran; put this mixture into the vessel containing the hundred quarts of beer; pour a part of this liquor into a copper, heating it enough to warm the whole when mixed together. Let it afterwards stand for six weeks or two months, or more, because the older this composition the better it is. The vessel should be covered with a cloth, and a plank over it, to preserve it from dust and insects, taking care only to let in air enough to encourage the necessary fermentation.

Cotton or thread to be dyed violet is cleansed as usual, preparing at the same time an astringent liquor, composed of, for every pound of the substance, two quarts of this black liquor and four quarts of water put into a boiler over the fire, boiling and skimming it for half an hour till no more scum rises, when it is taken off the fire, poured into a trough, and whilst no more than warm, four ounces of blue vitriol and one of saltpetre is dissolved in a part of this liquor. The skeins are returned in this astringent either warm or cold, where

they are suffered to remain for ten or twelve hours, and then wrung and dried. When ready for maddering they are well washed in running water, carefully drained, and then dipped in a liquor of Dutch madder, containing for every pound of the substance one pound of madder.

By this astringent it is easy to procure all the violet shades, from the pansy flower up to the lilac and grey violet; but experience is better than rules. If a dark violet be required, it is done by adding to this astringent two ounces of verdigris; or if still deeper, by galling the thread more or less previous to its being dipped, and by omitting the saltpetre. By augmenting the quantity of the latter and diminishing that of the blue vitriol, the violet will have more of the lilac, and by adding a little of the red astringent, more or less of the red. In short, different quantities of the black liquor and water, and different degrees of galling, will produce shades without number, and even different browns.

Of Red Cinnamon

This colour is nothing more than a mixture of yellow with the red of madder, which not being so free as the cochineal, is incapable of producing, by its mixture with the yellow, an orange colour like that ingredient.

Thread or cotton intended for this dye should be first cleansed and then dyed yellow with verdigris and weld, as above. When this dye has been well fixed, by dipping the skeins in a liquor of blue vitriol, about half an ounce to a pound of the substance, it is wrung and dried.

When dry they are galled, in the proportion of three ounces of galls for every pound, in the same manner and with the same precautions as I have related on the article on "Reds." When the skeins are dry they are alumed in the same manner as for

red, and afterwards maddered in the same manner, that is, a pound of madder to every pound of substance.

When the skeins are dried and washed they are dipped in a very hot soap water in the same manner as for yellow thread, but without boiling. The skeins are then returned till they become sufficiently brightened, and are divested of the superfluous vitriol by which the colour is tarnished.

Of Black

The various processes hitherto known for producing black on wool and silk, insufficient as they are with regard to those two substances, though generally followed, are still less proper for linen or cotton thread, the pores of which, as we have seen, are less open and less numerous. The various processes for dyeing black agree in the sole intention of introducing within the pores of the stuff ferruginous particles dissolved in different menstrua, and of precipitating them on the stuff by means of astringent substances furnished with phlogiston capable of colouring iron black. The best method therefore of succeeding, is to choose a solvent capable of dividing the particles so minutely that the calx may not injure the stuff. Copperas or green vitriol are used in these processes; but the iron it contains is by no means in a state of perfect division, on account of the phlogiston obstinately retained by the iron, which facilitates its union with the acid without the iron being perfectly dissolved. It is for this reason, doubtless, that a solution of green vitriol in water, deposits in lime a species of ochre which, according to M. Geoffroy, seems to be an extraneous substance. For the same reason the spirit of nitre, saturated with iron, will dissolve still more, by abandoning the grosser particles of what it first held in solution, and of which it retains only the phlogiston.

This being the case whenever copperas is used in dyeing of black, the stuffs dyed are generally harsh to the feel and considerably damaged, because the gross particles of the iron being only divided, and not dissolved by the vitriolic acid of the copperas, overfill the pores of the stuff into which they had entered, and by their hardness extending the partition of these pores force them asunder. M. Hellot very well observes that cloth dyed black without a blue or root ground, requires a greater quantity of copperas, by which the stuff is rendered rotten; but I have also remarked that when dissolving the rust of iron in vinegar, either for yellow or for the black of painted linens, it is apt to tear in the parts where these colours are applied, particularly if there has been no attention to take off the grosser earth by skimming the solution. To this earth therefore the rottenness of black stuff may be attributed, and not as vulgarly imagined, to the salt of vitriol, nor to any other burning cause.

And therefore, in order to render the colour more equal, and the stuffs less damaged, the best method for black is to use a solution of iron perfectly divided. Consequently, as experience daily teaches, those acids which attack the iron too rapidly are the least proper to produce a perfect solution of this metal. Weak acids are therefore preferable, which, notwithstanding their slow operation, penetrate entirely, dividing it into impalpable particles. This advantage is evident in the black composition which I have already given in the article on violets, serving as a basis to the black of linen thread and cotton and their shades; and which succeed much better in proportion as the black liquor is older, and consequently the solution of the iron more complete. The manufacturers in India are so truly sensible of this consequence, that many of them preserve their black vats for more than twenty years. In the states of Genoa, Florence, and Naples every manufactur-

ing city has a place of reserve, called the Seraglio, where at the public expense eight or ten vats are continually supported. These vats have been set from three to four hundred years, more or less; that is, prepared for the dipping of silk designed for black, and requiring only to be supplied with proper drugs in proportion as they are diminished by use; the ground remaining always the same, forms a kind of leaven, by which the fermentation of the necessary additional drugs is assisted.

The process at Rouen for dyeing linen and cotton thread black is first to give it a sky-blue ground, and then to wring and dry. It is afterwards galled—a quarter of a pound of galls for every pound of the substance (as for reds); having remained four-and-twenty hours in the gall liquor, it is again wrung and dried.

About five quarts of the black liquor for every pound is then poured into a trough (as described in the article on "Violets"). The cotton is then dipped and worked with the hand, pound by pound, for about a quarter of an hour; then wrung and aired. This operation is twice repeated, adding each time a fresh quantity of the black liquor, carefully skimmed; it is again aired, wrung, washed at the river, well drained, and dried.

When this cotton is to be dried, about one pound of the rind of the alder-tree for every pound of thread is put into a copper and boiled in a sufficient quantity of water during one hour; about half the liquor that had been used for the galling is then added, with about half the weight of the rind of the alder, of sumach. The whole is again boiled for two hours, after which it is strained through a sieve. When it is cold the cotton is dipped in it on the rods, and worked, pound by pound; from time to time airing, and returning it into the liquor, where having remained twenty-four hours, it is wrung and dried.

For softening this cotton when too harsh, it is the custom to soak it in the remainder of the weld liquor that had been used for other colours, adding a little of the logwood liquor; it is then taken out, and instantly plunged into a trough of warm water into which had been poured about an ounce of the oil of olives for every pound of the substance; it is then wrung and dried.

M. l'Abbé Mazéas has given a process for the dyeing of linen and cotton thread black, by maddering after having prepared with the *sickiou* of the Adrianople red, galling and dipping in an astringent composed of lime-water and green copperas calcined. This process, though long and expensive, is in my mind no better than those I have just described. In order to obtain a permanent black, it is my opinion that we must still have recourse to the black resulting from a combination of the three primitive colours, until we discover feculæ capable of yielding a direct black. I shall now describe a process in which I myself have succeeded perfectly.

Black for Linen and Cotton Thread by a Combination of Colours

It is necessary to begin by cleansing the thread as usual by galling, in the same manner as mentioned in the article upon red, aluming afterwards, and then dipping in a weld liquor. When taken out of this liquor it must be dyed in a decoction of logwood, to which has been added a quarter of a pound of blue vitriol for every pound of the substance. It is then taken out, washed at the river, wrung, and washed several times, but not wrung hard. It is at last dyed in a madder liquor, about half a pound of this dye for every pound of the substance. It is needless to repeat here the manner of galling, aluming, and welding, etc., having described them above.

By this process we may rest assured of obtaining a very beautiful and permanent black, that will not be liable to be discharged, provided that after having been dyed the thread be dipped in a boiling soap liquor.

Of Grey

Several different shades of grey are distinguished in the art of dyeing, viz., black grey, iron grey, slate grey, thorn grey, agate grey, etc. It is easy to conceive that grey in general, being a mixture of black and white, its different shades can be obtained only by introducing into the subject a small quantity of matter, by which the rays of light are absorbed in such a manner that some of the pores not being occupied reflect all the rays and present to the eye a grey colour, by means of the black particles contained in the intermediate pores. This operation in dyeing is therefore precisely the same as in painting, which produces grey by a mixture of lamp-black and of white lead.

It would be too tedious and even superfluous to describe the different processes for the several greys I have just mentioned. The dyer will be better able to judge of these shades by his eye than by any particular rules. All that can be said is, that it is the common practice to give a blue ground to black grey, iron grey, and slate grey ; but to none of the others. These shades require aluming in proportion to the shade wanted, and are even frequently galled with liquors that had been previously used.

The thread having been first galled, wrung, and dried, is dipped on the rods in a trough full of cold water, adding an arbitrary quantity of the black liquor and of the logwood decoction. The thread is then worked pound by pound, washed, wrung, and dried.

Of More Durable Greys

It is possible to produce permanent greys by the two following processes:—

First. By galling the thread by dipping in a very weak black vat or liquor, and afterwards maddering.

Secondly. By dipping the thread in a very hot solution of crystals of tartar, lightly wringing, and then drying. The thread is then dried in a decoction of logwood. It appears black, but by dipping the thread and working it attentively in a hot solution of soap, the superfluous dye being discharged, it remains a slate grey, very pretty and very permanent.

Of Musk Colour

The dyers of Rouen dyed this colour by galling, dipping in the black vat, afterwards welding, fixing, as already said, with verdigris, and at last dipping in the madder liquor. It is evident that all this still operates by a combination of colours ; but indeed this shade does not deserve so much trouble and expense.

Olive and Duck Greens

The various shades of these colours are all produced by giving the thread a blue ground, galling, dipping in the black liquor either strong or weak, then in the weld dye with verdigris (as mentioned in the article upon "Yellow"), fixing in a liquor of blue vitriol, and brightening with soap. These various shades merit no further detail, as the eye of the workman will be his best guide.

A very fine olive is produced by boiling in a sufficient quantity of water four parts weld to one of potash. You then

boil separately a little verdigris with some Brazil wood which had been steeped the preceding night; these solutions being mixed together in different proportions according to the shade required, the thread is then dipped in the mixture.

If you require a more permanent olive you make an astringent liquor composed of three ounces of alum, three ounces of nitre, two ounces of sea salt, and half an ounce of sal-ammoniac. The thread being well soaked in this astringent, and but lightly wrung and dried, is then dyed in the madder. This colour is extremely permanent, and it is easy to conceive that by varying the quantities of the madder and of the astringents, an infinity of shades may be obtained.

Of Browns, Maroons, Coffee Colours, etc.

It would answer no purpose to enlarge this treatise with a needless detail of all the possible methods of procuring the various shades of these several colours; the whole consisting in the use of gall, verdigris, blue vitriol, weld, and madder.

By welding of stuff previously maddered for red, you produce a gold colour; by dipping the same red in a blue vat, a plumb colour.

Of Silk Stuffs Dyed of Several Colours

The art of staining cloth, according to Pliny, came originally from the Egyptians; they most probably taught the Arabs the method of dyeing silk stuffs of various colours, as now produced in great part of Asia, and by the Saracens carried into Spain, where it is particularly in use.

The process of the Asiatics, more patient than ourselves, consisted in tying a number of knots on silk handkerchiefs, with so much address that when plunged into the liquor those

parts under the knots took none of the dye, so that the handkerchiefs when dried and untied, presented a red stuff strewed with yellow or white flowers very artfully imagined. The Europeans, in order to shorten the process, invented molds made of iron or lead, which being dipped in a prepared wax and previously applied to the silks or stuffs in flowers or compartments, preserved the parts which they would not have dyed from being penetrated. Many of these stuffs were sold about twenty years ago, some of them having a brown ground with red and yellow flowers, and some a red ground with blue and yellow flowers; these were called landerins, furies, foulards, etc., probably the names of the people by whom they were fabricated. The little care, however, taken in the manufacture of these stuffs, frequently very unequally woven, and made only of the refuse silk, or rather the subsequent introduction of the cirsakes, was the cause of their being entirely abolished.

The colouring substances employed for dyeing these stuffs red, as well by the Europeans as by the Indians, reside in the flower of that genus of plants called by the Greeks **Κνεκος** and **Φονος** by Theophrastus, *Atractylis, Sanguen Hominis, Virga sanguinea*. The original name of the species in question is doubtless *kartham*, so called by the Arabs and Saracens, by whose means we became not only acquainted with this plant itself, but with the method of using it. Before their irruption into Europe, several species of the *Cnicus* were discovered, from the branches of which issued a red colour, though not in a sufficient quantity for use. The species we now speak of was in Pliny's time unknown in Europe, as may be seen in Book xxi. chap. xv. where he says: "There are yet several common herbs; but they greatly prize the *Cnicus*, an herb unknown in Italy: nevertheless they do not eat it, but extract oil from the seed." The Baleyens at present regale with the seed, which they eat raw, and before it is ripe mixed

with an infusion of caleppe nuts. They make the same use of it in China, where it grows to a considerable height. In Asia it is called *Cassombe*; in Italy, *Croco sylvatico* and *Zaffarano sarracinesco*; and in France it is called *Carthame* or Bastard Saffron, *Carthamus officinarum flore croceo.* It has some affinity with the *Carduus benedictus.*

The flower from which the dye is extracted is composed of several petals, divided into five parts, of a yellow colour, but degenerating to red as the flowers begin to ripen. When ripe enough to gather, which cannot be done at once, the external petals which begin to droop, are first gathered, because the most red, leaving the small bunches in the middle. In proper time, when these bunches begin to ripen, and after some days to redden, they are also gathered. In gathering these flowers it is necessary to use some precaution, and therefore they cover the face in order to preserve it from the thorns. They are generally gathered either in the morning or evening, when the stalks are less strong, consequently less dangerous: some of the flowers are left for seed.

The Indian women bruise the flowers of this plant with rice meal and a little of the decoction of the caleppe nuts, for painting their faces. The Saracens probably introduced this composition into Spain, from whence the fashion passed into France. Certain it is that with the flowers of carthame they formerly made a red paint for the toilet, known by the name of rouge d'Espagne; but since the discovery of cochineal this rouge gave place to carmine. Some, however, complaining of the effects of carmine, which is not always divested of the acid, returned to the rouge d'Espagne, making it a mystery, and vending it as a novelty.

I shall now give the Asiatic process for dyeing their cloth and silk stuffs with these flowers. They take a certain quantity, which they divide into two equal parts, which they spread

on two pieces of white cloth, supported by rods as for filtering. They put a vessel under each cloth, and then pour clean water over it, till it is no longer coloured by the flowers.

The first water is a deep yellow, and good for nothing. For this reason some of the Indians reject this method, and begin by divesting the flowers of their first dye by washing them in running water, forming them into balls, and drying them in the sun for use. Almost all the rest of Asia, particularly the Baleyens, who excel in this dye, dry their flowers without washing. They have afterwards more trouble in extracting the yellow colour, but are persuaded that the red is much more permanent.

When the water poured over these flowers contains no more of the yellow colour, the Indians plunge their cloth into the second water, which has but a slight tint of yellow. When it is well drenched, this water is thrown away, and the cloth is again dipped in the second, and so on to the third, which operation lasts about two hours. The cloth having imbibed in these waters a slight tint of carnation, is afterwards taken out and dried.

The flowers, when entirely divested of their yellow colour, are pounded, and by the Indians made into a paste, which they put into an earthen dish, as a metal vessel would counteract the success of the operation. They likewise put into another dish a handful of the ashes of the rinds and leaves of six different plants, not at all essential to the operation, since in some places they use for this purpose a salt brought from Siam, where, in certain provinces, and at certain seasons of the year, they find it on the surface of the earth. They imagine, however, that this lixivium is too strong for their fine cloth, having remarked that one ladle of this lixivium is as acrid as six times as much of any other.

It is very probable that this salt is nothing more than the

nitre of the ancients, in our time known by the name of natrona, which is an alkaline salt of the nature of mineral alkali, found in Egypt and other hot climates, crystallised amongst the sands bordering on certain salt-water lakes. It is generally mixed with a quantity of marine salt, which gives it great acrimony.

The Siam women prepare this colour, and add to the ashes already mentioned several aromatic herbs, to drive out, as they say, the bad air, adding other ceremonies; several of them, however, dispense with these ceremonies, only using good ashes and choosing a mild season for the preparation of this colour in the following manner:—

They take a pinch of the ashes for every handful of flowers; they knead it, till being well mixed, without any addition of water, they form a mass into which they make many incisions with a knife, from whence issues a very dark red juice. This paste is divided into two equal parts; they then spread two bits of linen on rods, in a loose manner, putting in the middle of each cloth one or two leaves of arum, through which they make a hole in order to facilitate the draining of the dye. For this purpose they make use of wild arum, the leaves of which are eighteen inches broad.

Having placed these leaves on the cloth and upon each a part of the paste, they pour clean water (rain water to choose) over one of them, which is received by a vessel underneath the one that drains, in order to pour it over the other; they add fresh water to the first, which is afterwards poured over the second, and so on till the water has no more colour. These waters are kept separately, in order to use upon occasion that which is more or less charged with the colouring matter. The dregs of the flowers being exhausted of colour are thrown away as useless.

The colour thus extracted is a dark red, but not very pleasing; they brighten it, however, by pouring into each vessel con-

taining the different infusions, a small quantity of lemon juice of the sourest kind. The Baleyens not having many lemons in their country, substitute in their stead the pulse of tamarinds infused in water, and in want of these make use of the juice of barberries.

This juice being poured into the coloured liquors, immediately changes them to a bright red colour, the shade of which is nevertheless proportioned to the quantity of colour contained in each vessel, so that the vessel which had received the first infusion, being more saturated than the last, becomes a rose colour, which is of admirable use in the different shades of this dye.

For this purpose, having knotted the cloth as I have already said, they pour a certain quantity of water into a vessel proportioned to the quantity of cloth. To this is added some of the clearest of the dye, into which the cloth is plunged till it has taken all the colour. The water is then thrown away, and the cloth lightly wrung, and again immersed in fresh water, to which is added a fresh quantity of the dye. The weakest in colour having been used, the following is taken, till that also being exhausted, they finish with the first, which is the darkest; but this last they never use for rose colour, reserving it for the darkest reds, and for those cloths which they would have almost purple.

When their cloth is dyed they dry it in the air, but not in the sun. The next day they dip it lightly in lemon juice, and again dry it. The cloth thus dyed is of a rosy red, a little inclining to violet. The Asiatics consider this shade as a modest colour, proper for grave persons and mothers of families.

To enliven this red and make it more of the scarlet, they add to the flowers, whilst bruising, a little *Curcuma*, which brightens more or less according to the quantity added. Of these calicoes they make handkerchiefs for presents from lovers

to their mistresses ; pocket-handkerchiefs, veils for their women, and turbans.

These colours are extremely delicate, very liable to be damaged by the least moisture or rain, and so easily changed, even by the air, that as soon as they come within doors they fold their handkerchiefs up, wrap them in paper, and carefully lock them in drawers to prevent them from being rumpled. They even carry this attention so far as to repair the injury they had received by dipping them the next day in an infusion of caleppe nuts with lemon juice.

The Baleyens and the inhabitants of Java fancy that the Carthamus furnishes a more permanent colour in their own country, because that instead of lemon juice they use the pulp of the tamarind, which they call *Badong,* and which our botanists call *tamaringus.* This fruit is the produce of a tree growing in Ceylon, in height, and the shape of its leaves, something like that producing the nutmeg.

The Manner of Stamping Silks, etc., in Europe

For this purpose they use landerins, thin taffetas, and slight silks. The red with yellow flowers are first dyed yellow with *Terra-merita,* to which some add fustic. This colour, though pleasing, has but little solidity ; and is used only because the stuffs are low priced. It might, however, be fixed by the methods I have described in the dyeing of cotton thread.

When the stuffs have been thus dyed yellow and dried, the prepared wax is applied on such parts as are meant to remain yellow, in the following manner :—A wooden block is engraved in flowers or compartments. The impression is then taken off in sand, into which molten lead or tin being poured, forms a block of lead or tin similar to the wooden one. It should have a button or handle for the conveniency of hold-

ing. The stuff is spread on a table and the mould impregnated with the wax by means of a leather cushion, and then applied to the stuff.

This composition consists of four parts suet and one part wax, melted in a sufficient quantity of oil. The stuff thus printed requires nothing more than to give it the red dye in the following manner:—

One pound of *carthame*, or bastard saffron, or more according to the quantity of the stuff, is put into a linen bag and well washed at the river till the water comes off clear and without colour. It is then taken out of the bag and dried in the shade. A quarter of a pound of Alicant soda, being pounded, is put over a clear fire in order to evaporate the moisture as much as possible. When dry it is mixed with saffranum, previously broken with the hand to prevent it from gathering into lumps, and to facilitate its mixture with the soda. This mixture is afterwards put into a white linen bag, fastened in such a manner as to leave sufficient room. The bag is then put into a vessel with a hole in the bottom, to which is applied either straw or sponge, as for filtering a lixivium. Another vessel is placed underneath to receive the boiling water thrown over the bag, and which becomes red gradually. If deficient in colour, notwithstanding that the *saffranum* is of the best quality, it proceeds from the weakness of the soda. This must be immediately remedied by pouring into the upper vessel a fresh quantity of the lixivium. Half a pint of lemon juice or more, is then poured into the coloured water, till the liquor becomes of a fine cherry colour. This the workmen call turning the liquor, because it is really turned by the lemon juice, the affinity of the acid with the alkali causing a precipitation of the red feculæ. The liquor being well stirred, the stuff is put into it, turned, and carefully aired till it has taken the colour.

This colour may be enlivened by pouring lemon juice into water, and when ready to boil, by dipping the stuffs, it serves both as a wash and brightener. To procure a colour more on the scarlet, the stuffs, previous to their being dyed, may be dipped in a liquor of *Terra-merita* or roucou, without the least difficulty. These dyes, as I have already observed, require no aluming.

The lemon juice solution, which should be used very hot, serves to detach the composition of wax which had been applied to the stuff, which as it becomes detached, and rises to the surface of the liquor, ought to be carefully skimmed.

It is very evident that the Asiatic process is greatly abridged. It is doubtless convenient to simplify all processes as much as possible, but may they not be too much abridged? We see that the Baleyens boast that their dye is more permanent than that of other nations. We perceive also that they succeed better in this colour and all its shades at Lyons than at Paris. May not this difference be partly attributed to the acid of the tamarinds, used by the Baleyens in preference to lemon juice; and at Lyons to the superior quality of their lemons? This seems more probable than to suppose that it proceeds from any difference in the waters. I have myself used the juice of the hip or briar fruit, much to my satisfaction, as well with regard to the colour as to the expense; this shrub being very common, and nothing so easy as to procure the fruit at a very small expense.

Many of the Indians are accustomed to add to this dye an infusion of the caleppe nut, which is now discontinued as useless. The little solidity of the feculæ of the *carthame,* owing to the volatility of the essential oil, which serves as a basis to this resin, it is easy to imagine that by mixing it with an oil, not volatile, the colour may be fixed. I would recommend such kind of experiments to those who are at leisure.

This article I shall finish by observing that custom having established the washing of all linens and cottons in lixiviums, or soap and water, we are thereby deprived of a great number of agreeable colours. The carthame colour when faded may be revived by dipping it in lemon juice and water. Many other colours, though yielding to fixed alkali, would nevertheless resist the power of the air, and therefore linen and cotton threads of this dye when fabricated into stuffs, might be cleaned with a solution of alum and crystals of tartar, instead of soap.

Of a Linen with a Blue Ground and White Pattern

In imitation of the silk stuffs above mentioned, a method has been invented of dyeing linen or cotton blue, and of reserving the pattern or compartments by means of a composition which, obstructing the pores of the cloth, wherever applied, prevents the dye from penetrating. These were the first imitations of painted linens, commonly called chintz.

For this purpose a mould is prepared by driving with a hammer into a block of hard wood, nails of various sizes, differently figured and at distances proportioned to the design of the impression. These nails should be either of iron or of copper; and when fixed in the block should be again polished with a file, as well to rectify the injuries of the hammer as to make them of an equal height. They should be three inches above the plank, and the plank itself should be three inches thick, that it may be less liable to crack by the heat of the composition. Some workmen previously boil them in oil, which renders them more compact, and more capable of resisting the heat without warping.

The stamps being thus ready for the impression, a mixture is then prepared, made of four parts good suet, two parts of

arcanson and one of yellow wax, simply melted in a skellet over a slow fire. The stamp having been soaked in this hot mixture, is immediately applied to the cloth, which is spread on a table, horizontally fixed, and covered either with cloth or flannel. It should be perfectly even, with a ledge or border, about the third of an inch high, filled with sand, equally distributed on the cloth by means of a sieve. This sand prevents the composition, which hardens as it cools, from sticking to the cloth that covers the table.

It is easy to conceive that the stamps should be either a perfect or an oblong square, and that the linen should be fixed on the table in a straight line, so as that the two selvages may be right and left of the printer. These stamps are furnished at the four corners with corresponding wires, as a guide to the printer, indicating the precise spot where the stamp should rest at the second application. These wires should be so placed as to cover the larger nails of the following impression, that the marks they make, being concealed by a greater quantity of the composition, may leave no blemish in the work. The printer having finished the first impression, plunging the stamp a second time into the hot composition, makes a second, and so proceeds till the whole of the cloth is stamped. Having come to the right-hand selvage, he returns to that on the left, and so on till he comes to the edge of the table, throwing the finished part behind, putting fresh sand if necessary, levelling it only with a ruler, that the cloth may lie even.

The linen thus stamped is then dyed in a cold blue vat, the description of which I have given above. Having taken the shade required, it is aired, washed at the river, and dried. A copper is then prepared with a sufficient quantity of water, into which, when ready to boil, the linen is plunged at several times with a pole. The composition being detached by the

heat of the water, rises to the surface, which with the skimmer in one hand is taken off, whilst with the other the linen is kept under the liquor to prevent the composition from again adhering to any part of the cloth. When the composition ceases to rise the cloth may be taken out, again washed at the river, drained, and dried. The ground of the cloth being thus dyed blue, the parts reserved by the composition remain white.

It sometimes happens, however, that the reserved parts are not perfectly white, having a reddish cast, which must be owing either to the bad quality of the wax or to the too great fierceness of the fire. It is therefore necessary to be careful in choosing the wax, and in preserving a moderate heat. Some workmen for this purpose, and to spare the indigo, daily increasing in price, only half ground the cloth in the indigo vat, finishing with a logwood liquor, which is a great saving of the indigo; nor is this fraud perceptible, because the cloth when soaked, if properly dyed, retains a great part of the logwood.

By means of these stamps, however, it is impossible to make any other than compartments, the lines of which must be interrupted by the hollows between the nails. If therefore you mean to print flowers, the stamps mentioned in the article on dyeing silk of two colours are the most proper.

But as in this operation the wax is liable to break, because hardened by the sharpness of the vat, other compositions are invented, less injurious, and more capable of being used with the common wooden moulds. The following is the simplest and the best:—

Dissolve in a small quantity of water two ounces of blue vitriol and as much verdigris. A pound of white pipeclay with one ounce of arsenic is then bruised on a marble, and the whole mixed together over the fire, till it is perfectly incorporated, adding at last half a pound of gum arabic

powdered and one spoonful of linseed oil. This composition should be thinned with a sufficient quantity of water, till of a proper consistence; but if too thin for the stamp, it may be thickened with starch and blue vitriol.

For linens or cottons stamped with this composition, the dye I have mentioned is generally used; but then it should be prepared in different vessels, because linens done with the last reserve, not being so stiff as with the composition of suet and *arcanson*, will be injured by being rumpled, which in the brandy pipes cannot be avoided.

Square vats are therefore constructed about six feet deep and three and a half wide and about three feet in the ground, for the convenience of the dyer. The cloth is then fixed by the selvages to two wooden frames, each composed of four bars, and of such a length as to be easily moved backward and forward in the vat. These frames are held together by means of a screw, so as to be easily let out or taken in, according to the breadth of the cloth.

The cloth is supported by little iron hooks passed through the selvage at the opposite sides, to keep it as it were in folds throughout the piece.

The cloth thus arranged is suspended with a pulley over the vat by means of cords fixed to each corner of the frame, and uniting in the middle, so that by slackening the pulley the linen is dipped without being rumpled. When necessary to air and ungreen, by drawing the pulley the frame rises and the cloth drains into the vat.

These vats are commonly made of wood with iron hoops, to prevent them from warping; nevertheless they are so liable to come asunder that it is much the safest way to construct them of lime and cement. I have seen very solid ones composed of four squares of hard stone, with a bottom of the same, the liquor being secured from leaking through the joints by a mastic.

By this manœuvre, though cotton velvets are dyed blue without being rumpled or rolled, it does not, however, prevent them from being watered and spotted, which can never be avoided, because the indigo does not yield to the cold vat without the assistance of salts, and these salts cannot be prevented from falling to the bottom of the vat. On this account, though a disagreeable colour, it is the custom to dye cotton velvet with logwood or Saxon blue, which having no solidity soon fades when exposed to the air.

There is, however, a method of giving cotton velvets a blue surpassing all the pastel and indigo blues, being, when compared to them, like scarlet to all other reds. This dye perfectly resists the air, and is no less proof against the alum and tartar boilings. It is as brilliant and durable in wool as in silk; but as this is an entire secret, and the result of my own experiments, I must be excused from the communication.

Of Saxon Blue

I shall not now give the process of a dye so little used either for cotton or linen thread, because the colour when exposed to the air soon fades; neither will it stand soap boiling. It is nevertheless used in some places for cotton velvet.

The composition of this blue is nothing more than a division of the feculæ of the indigo by vitriolic acid.

For this purpose, by pouring four ounces of common oil of vitriol over half an ounce of well-chosen indigo pulverized, you instantly produce a considerable rarefaction of the feculæ. The whole is left to digest in a moderate heat for twenty-four hours, till the effervescence ceases, an ounce of orpiment powdered is then added to the mixture, which being stirred with a stick, is left to stand till wanted.

The cotton velvets being sufficiently washed and cleaned,

some ladles of the composition, according to the shade required, are poured into the same liquor, which ought to be very hot, though not boiling. The velvet is then laid on a winch across the copper, which is very rapidly turned to the end of the piece, and then the contrary way, that the velvet may be equally dyed; which when it has imbibed the shade required is taken out.

For green, you dye the stuff with *curcume*, as I have already described, in which case it is of no consequence whether it be dyed yellow before or after the blue. It is even possible to dye both in the same liquor.

Observations on this Dye

M. Gode in the year 1770 presented a memoir to the Academy of Sciences at Rouen, in which he pretended that by pouring vitriolic acid on this feculæ, he produced a combination of this indigo with the vitriolic acid. The appearance of the Saxon blue liquor, in which the feculæ are suspended but not dissolved, is alone sufficient to prove the contrary. Whatever he may still say, it makes no difference, nor does it make any exception to the property of acids, by which blue dyes and vegetable violet are changed to a red, because it is not on feculæ such as indigo that acids produce this change, but rather on vegetable juices, the colour of which depends on the salts and essential oil of the plant (see M. Geoffroy's memoir in the *Transactions of the Royal Academy of Sciences*).

THE END.

INDEX

PART I

THE ART OF DYEING WOOL

PART II

THE ART OF DYEING SILK

PART III

THE ART OF DYEING COTTON AND LINEN THREAD

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